POWER

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The Old Standby

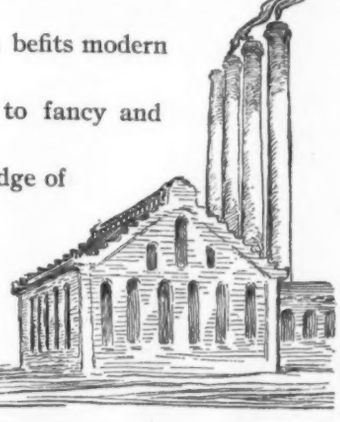
By R. T. Strohm

SUNDAY SUPPLEMENTS often attract our attention
By printing, with scareheads two inches in height,
An extended account of some splendid invention
Whose wonderful value has just come to light.
We are calmly assured that, for turning out power,
This latest contraption will soon be supreme,
But its memory lives for a day or an hour,
And still we rely on the pressure of steam.

Just as likely as not, it's a new style of turbine,
Designed to be run by the ambient air,
And adapted for service in regions suburban,
In cities, in deserts, and most anywhere;
Or if not, it's a waterwheel, complex and weighty,
Intended to turn in the rush of a stream,
With a total efficiency far above eighty—
Yet still we depend on the power of steam.

Now and then it's a form of perpetual motion,
Producing its energy quite without cost,
Or perhaps it's a wave motor set in the ocean
To harness the forces that long have been lost.
And our minds are amazed at the marvels of science
Displayed in each clever, ingenious scheme,
But we pass them all by, and we pin our reliance
On motors deriving their power from steam.

We are told that the gas engine sooner or later
Will drive out the type that we credit to Watt,
But as gas-fuel prices grow steadily greater,
Deep down in our hearts we are sure it will not.
So we dig out our books, as befits modern toilers,
And leave the romancer to fancy and dream,
While we add to our knowledge of engines and boilers,
Convinced that there's always a future for steam.



Diesel-Engine Central Station at Winchester, Ind.

By Thomas Wilson

SYNOPSIS—A 400-kv.a., two-unit plant generating current for light and power and the pumping of city water. Fuel costs less than ¼c. per kw.-hr. The operating cost is 0.457c., and including overhead, the total cost is 0.96c. per kw.-hr.

In the past few years the Diesel engine has made rapid progress, and it is now generally conceded that there are certain fields in which it excels. Where oil can be bought at a reasonable figure, these engines, as now made, show remarkable results. The initial expense is high, but this is offset by an operating cost so low that the total per unit of output will fall below that of the average steam plant. There are no stand-by losses, and with proper care, maintenance is no higher than with steam. The engine may be brought into service on short notice, and the labor required to operate is less than would maintain a steam plant of equal capacity. In plants under 1000 hp., such as would be employed in small factories or for the lighting of small towns, the Diesel engine is at its best.

An interesting example of a small central station tending to prove the above assertions may be found in Winchester, Ind., which has a population of 5100. The plant, which is operated by the Citizens Heat, Light & Power Co., contains two 200-kv.a. units, furnishing commercial and street lighting for Winchester and four adjacent towns. Power service is supplied over the same circuits, and at the station, current for pumping water to the home town and to run the air compressors serving the prime movers. Three-phase current is generated at 2300 volts. During the day one unit will carry the load, which runs up to 160 kw. At the peak, which lasts from 5 to 10 p.m., the load is practically double, and in the morning hours it is comparatively light. It is thus evident that one machine must be operated continuously and the other for five hours, the two running in parallel. During the latter period there is no reserve unit. Both machines must operate every day, and for the past two years and three months, during which they have been in service, this schedule has been maintained without a shutdown.

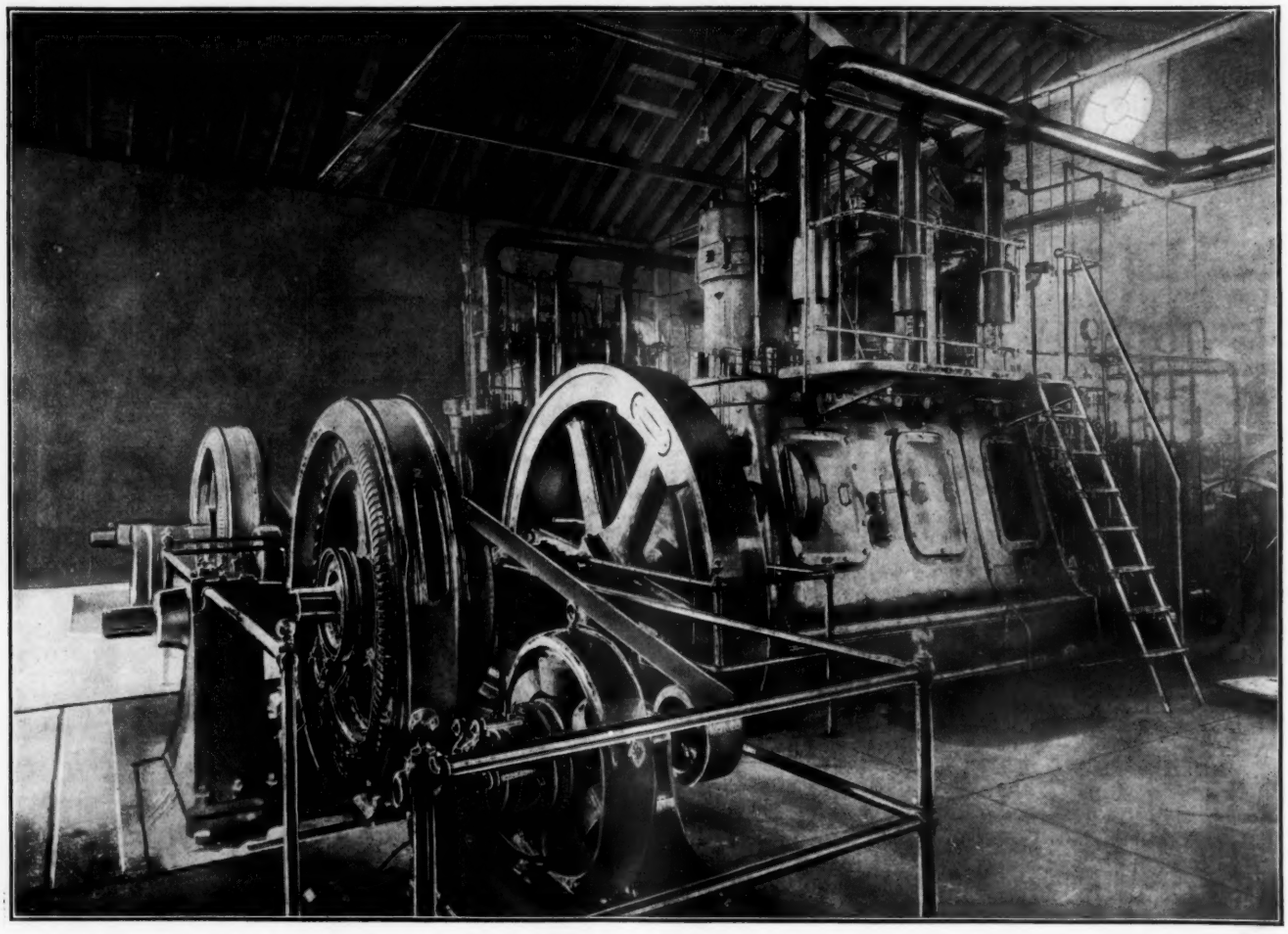


Fig. 1. Diesel-Engine Units

The engines are of the three-cylinder vertical type, 16x24 in., with a speed of 165 r.p.m. They are rated at 225 hp. and are connected directly to 200-kv.a., three-phase, 60-cycle generators, which, at 80 per cent. power factor, will deliver 160 kw. As shown in Fig. 1, the exciters are belted to the shaft. The latter machines are

rated at 11 kw. and are driven at a speed of 600 r.p.m. The two units are exact duplicates.

Air for fuel injection and starting is supplied by two three-stage, motor-driven air compressors and is stored at a pressure of 60 atmospheres, in 10 steel bottles. This is equivalent to 882 lb. per sq.in., and on heavy loads the pressure is run up to 955 lb. When only one engine is running, the smaller compressor, which has cylinders 8, 5 and 2⅜ by 8 in., is operated. This machine is belt-driven by a 25-hp. induction motor. The other compressor, which has cylinders 10, 6½ and 3 by 12 in., is large enough to serve the two engines, and is operated during the peak load. It is belt-driven by a 50-hp. induction motor.

Jacket water is drawn directly from the mains and is returned to the reservoir, located near the plant. As a large quantity is used for this purpose, the rise in temperature is small, so that no lime is deposited in the jackets.

Fuel is stored in an underground oil house located between the plant and the railway. It has two 8000-gal. tanks, which are filled by gravity from railway tank cars. An interesting method was used when installing these tanks. Everything, including the foundation, was made ready for their support. The pit was then filled with water and the tanks rolled into the opening. As the water was pumped out, they gradually settled and were guided into place with little difficulty.

From the underground storage two elevator tanks in the engine room are filled with oil by a motor-driven pump, or by a hand pump which has been provided to guard against emergencies. From this elevated location on the engine-room wall, the oil flows by gravity through a strainer to the fuel pumps, which force it up to the

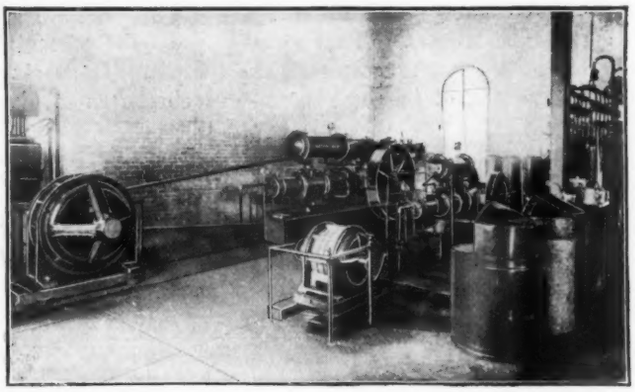


FIG. 2. MOTOR-DRIVEN, THREE-STAGE COMPRESSOR

fuel valves. A meter attached to each engine measures the quantity of oil in gallons, and a gage shows the pressure in the air line.

The plant is equipped with an uptodate switchboard consisting of nine gray-slate panels, carrying horizontal edgewise ammeters and voltmeters, polyphase integrating wattmeters, induction watt-hour meters on the different circuits, a synchronizing indicator, a power-factor indicator and a Tirrill voltage regulator. The switches and copperwork are standard throughout.

Water for the City of Winchester is obtained from a reservoir on the premises, which is supplied from seven 8-in. wells 190 ft. deep. A pressure of 45 lb. is maintained on the system, and in case of fire it may be run up to 95 lb. To supply this water, three triplex power pumps are installed in the station. Two of these have a capacity of 250,000 gal. each per 24 hr. One is driven by a synchronous motor which has double the capacity needed and is over-excited to raise the power factor on the electrical system. The other is driven by a 40-hp., 8x12-in., three-cylinder gas engine. A large fire pump of the same general design, driven by an induction motor, is also installed. Its capacity is 450,000 gal. per 24 hr. Ordinarily, one of the smaller units will supply the demand for water. In case of fire the second small unit, or the fire pump, which is large enough to supply all requirements may be started. Natural gas from a

FIG. 3. SWITCHBOARD

commercial pipe line is used in the gas engine. An additional source of power is thus afforded that will tend to prevent a shutdown should anything happen to the electrical plant.

COST OF THE EQUIPMENT

Table 1 gives the cost of the generating equipment as entered on the company's books. The engines, air compressors and everything required for their operation cost $29,000; the generating equipment, $5000; foundations and installation, $2000; making a total of $36,000. Per kilowatt of generating capacity, this reduces to $112.50. Adding to the above total the cost of the switchboard, the building and the oil-storage tanks, gives a total of $52,000, or $162.50 per kilowatt of generating capacity. Compared to the cost of a steam plant per unit of generating capacity, this is high. Interest and depreciation on this figure naturally handicap the plant, but are more than offset by the low operating cost.

TABLE 1. COST OF GENERATING EQUIPMENT

Engines and air compressors	$29,000
Generators	5,000
Foundations and installation	2,000
Switchboard	6,000
Building and oil tanks	10,000
Total	$52,000
Rated engine horsepower	450
Generating capacity, 80% p.f., kw.	320
Cost per horsepower	$115.55
Cost per kilowatt	$162.50

TABLE 2. OIL USED AND COST PER UNIT

Months	Kw.-Hr.	Gal. Oil	Oil per 100 Kw.-Hr., Gal.	Cost of Oil at 3c.	Fuel Cost per Kw.-Hr. Cents
November, 1914..	107,270	8,280	7.7	$248.40	0.2316
December, 1914..	119,560	9,250	7.7	277.50	0.2321
January, 1915....	94,010	8,930	9.5	267.90	0.2849
Totals	320,840	26,460	8.2	$793.80	0.2474

Data taken from the log book for the three months previous to the writer's visit show that the load averaged over 100,000 kw.-hr. per month. The quantity of oil used averaged 8.2 gal. per 100 kw.-hr., which is a trifle under

0.6 lb. per kw.-hr. The fuel oil used ranges in density from 32 to 34 deg. Baumé and its cost delivered in tank-car lots was 3c. per gal. Dividing the total cost of the oil by the total output in kilowatt-hours, the average fuel cost for the three months was 0.2474c. per kw.-hr. This is much less than in an average steam plant of the same capacity.

Table 3 gives the operating, overhead and total costs

TABLE 3. GENERATING COST AT SWITCHBOARD

		C. per Kw.-Hr.
Fuel at 3c. per gal.		$0.2474
Labor (One chief engineer, $75 per mo.; One assistant engineer, $60 per mo.; One night engineer, $60 per mo.)	$195	0.1823
Maintenance per month, $926		0.0086
Supplies, lubricating oil, waste, etc., $20 per month		0.0187
Operating cost		$0.4570
Overhead: Interest, depreciation and taxes, 12½% on $52,000		0.5065
Total cost		$0.9635

of power generation. It will be noticed that only three men are required to run the plant continuously, but during the writer's visit two were carrying on the work, an accident to the chief engineer having kept him away.

The two Diesel-engine units were started Dec. 1, 1912, and during the 27 months of operation about $250 has been expended for maintenance. The equipment is, of course, new, but indications are that this item will not materially increase for years to come. The superintendent who has charge of the executive work of the company, and incidentally keeps his eye on the plant, is an experienced Diesel-engine operator, and this has something to do with the maintenance item. Lubricating oil, waste and supplies averaged $20 per month. The sum of the various operating items is only 0.457c. per kw.-hr., and when an overhead of 12½ per cent. is added, the total is below 1c. per kw.-hr. delivered to the switchboard. This showing is exceptional for a small plant, and if the load should increase up to the capacity of the generating units, the overhead cost per unit will be reduced, which in turn will lower the total operating cost appreciably.

To O. N. Eiler, superintendent of the company, we are indebted for the information contained in this article.

PRINCIPAL EQUIPMENT OF WINCHESTER OIL ENGINE PLANT

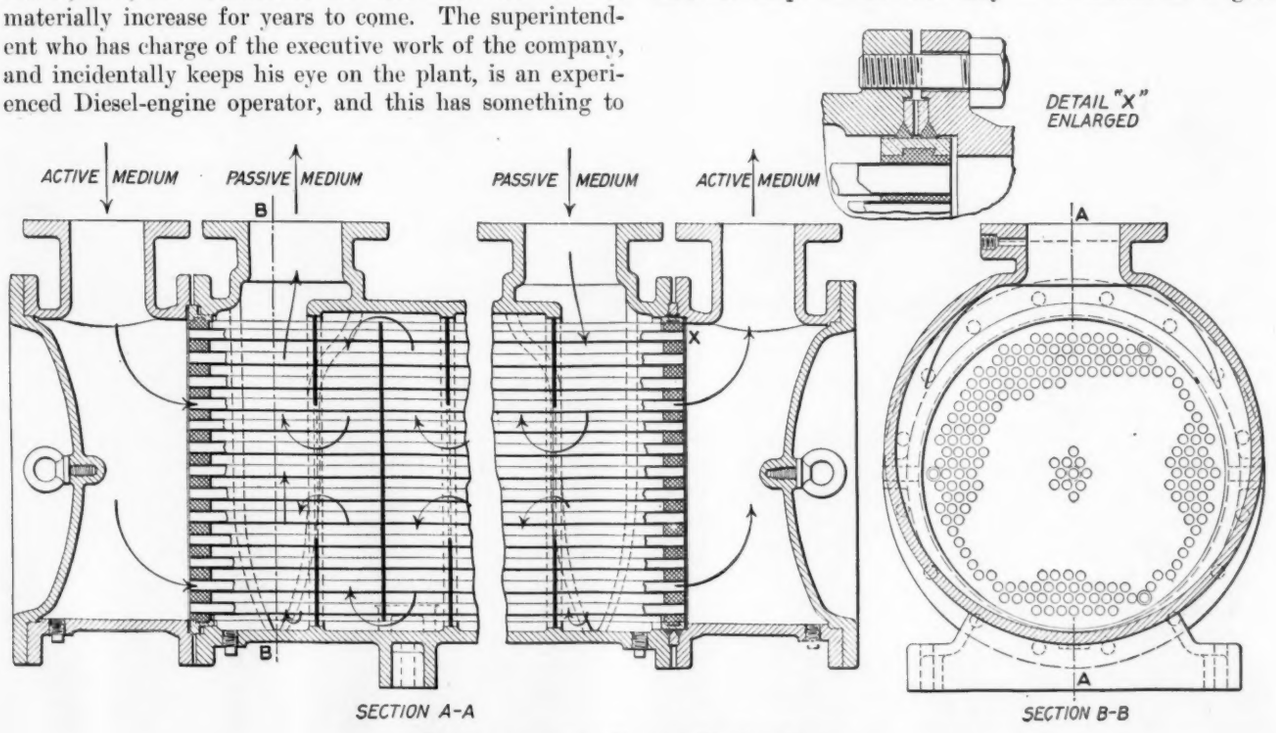
No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Engines	Diesel	3-cyl., 16x24-in.	Generating units	32-34 deg. oil, air 60 atm., 165 r.p.m.	Busch-Sulzer Bros. Diesel Engine Co.
2	Generators	Three-phase, 60-cycle	200-kw	Generating units	2300-volt, direct-driven by Diesel engines	(Fort Wayne) General Electric Co.
2	Generators	Direct-current	11-kw	Exciter	125-volt, 600 r.p.m., belt-driven	(Fort Wayne) General Electric Co.
2	Air compressors	Three-stage	8x5x2¾x8-in. 10x6¼x3x12-in.	Air for Diesel engines.	60 atm., belt-driven by induction motors	Ingersoll-Rand Co.
1	Pump	Triplex	7¾x12-in	Pump city water	Chain-driven by Fort Wayne synchronous motor	Goulds Manufacturing Co.
1	Pump	Triplex	7¾x12-in	Pump city water	Driven by 40-hp. Nash gas engine	Goulds Manufacturing Co.
1	Pump	Triplex	11x12-in	Pump city water	Driven by 50-hp. independent motor	Goulds Manufacturing Co.
1	Pump	Centrifugal	1-in	Oil from storage to tanks in engine room	Driven by 1-hp. motor	Chas. S. Lewis & Co.
1	Hand pump		1-in	Oil from storage to tanks in engine room		Trahern Pump Co.
2	Meters	Integrating		Measures oil to engines		National Meter Co.
2	Gages	Indicating		Pressure in air line		Schaeffer & Budenberg Mfg. Co.
4	Lubricators	Force feed	Three feeds	Lubricate cylinder of engine and air compressor		General Electric Co.

Switchboard and all instruments.

The S. & K. Oil Cooler

The essential feature of the S. & K. oil cooling apparatus is its high efficiency, which is attained by the arrangement of the cooling surface and the method used to pass two mediums through the apparatus, exchanging the heat through the tube walls in counter currents. As the thickness of the tubes has considerable influence on the heat condition, comparatively thin walls are used, which also make a saving in weight and space.

The tube sheets of the apparatus are built of metal in which the tube ends are cast, and therefore the spacing and the shape of the tube may be so chosen as to give



DETAILS OF THE S. AND K. OIL COOLER

the best results in heat transfer, instead of being determined by the strength of metal required for expanding, rolling or inserting of the tube end and spacing the tubes.

This oil cooler serves the purpose of removing the heat from the lubricating oils used on bearings and can be used in any forced lubricating system. The arrangement consists of a continuous circuit in which the oil is taken by pumps from the bearings and forced through the apparatus, where it is cooled and then returned to the bearings.

In order not to block the supply of cooled lubricant coming from the machine, the hot oil is removed quickly and rapid circulation is obtained, which is a factor in cooling the bearings.

The illustrations show an important part in the construction of the cooler. The arrangement of packing prevents any mixing of the oil and water, and any leakage will come to the surface and be at once detected. The apparatus requires a small pump for water, which keeps down initial cost and operating expenses. The water passages can be cleaned by removing the cover without disconnecting any pipe, and the whole tube bundle can be withdrawn to inspect the outside of the tubes. The oil cooler can be used in any position, but it is better to use it in a vertical one, as the flow of both water and oil is more uniform, and any sediment in the oil will settle at the bottom and is easily removed.

The appliance is manufactured by the Schütte & Koerting Co., 12th and Thompson St., Philadelphia, Penn.

The Specific Heat and Heat of Fusion of Ice

By H. C. Dickinson and N. S. Osborne

Results of previous determinations of the specific heat of ice by certain observers have indicated a rapid increase in the specific heat on approaching the melting point, whereas A. W. Smith* has found the heat capacity of ice to be practically constant up to temperatures close to zero.

The present investigation has been undertaken with the object of securing further evidence as to the thermal behavior of ice at temperatures near the freezing point and of obtaining reliable data for the construction of tables of the total heat of ice and water in the range of temperature with which refrigerating engineers are concerned.

The measurements were made by means of a calorimeter of aneroid type, i.e., without stirred liquid as calorimetric medium. The samples used were from 400 to 470 grams each. Three were of redistilled water of fairly high purity, while a fourth, which was distilled directly into the container, appeared from the experimental results, to have a much higher degree of purity.

In the determinations of specific heat it is found that over the range of temperature covered by the experiments (—40 to —0.05 deg. C.), the specific heat S in 20-deg. calories at any temperature θ of the four ice samples is represented within the limit of experimental error by the equation

$$S = 0.5057 + 0.001863\,\theta - 79.75\,\frac{l}{\theta^2}$$

in which the constant l is assumed to represent the initial freezing point of the specimen and has the following value: Sample No. 1, —0.00125 l; No. 2, 0.00120 l; No. 3, 0.00095 l; No. 4, 0.00005 l.

[The large calorie, or French heat unit, is usually taken as the amount of heat required to raise one kilogram of water one degree Centigrade, or from 15 to 16 deg. C. The "20-deg. calorie" as used by the authors means the heat necessary to raise one kilogram of water one degree Centigrade at 20 deg. C. instead of at 15 deg. C.—Editor.]

From the fact that the term which represents the departure of the specific heat from a linear function of the temperature is found to depend on the purity, being less the higher the purity of the ice, it is concluded that the specific heat of pure ice in 20-deg. calories may be closely represented by the equation

$$S = 0.5057 + 0.001863\,\theta.$$

Determinations of the heat of fusion made upon three of the samples used for the specific-heat determinations gave the following values: Heat of fusion of sample No. 1, 79.68 cal.; No. 2, 79.85; No. 4, 79.75; mean, 79.76 cal.

The results of a previous investigation at the Bureau of Standards using different methods to determine the heat of fusion of ice give, when corrected for the newly found value for specific heat, a mean value of 79.74 20-deg. calories.

The mean for the two investigations is 79.75 20-deg. calories per gram.

For the use of engineers a table of total heats of ice and water is given, expressed in B.t.u. per pound at temperatures from —20 to +100 deg. F.

TABLE OF TOTAL HEAT OF ICE AND WATER

Temperature of Ice t Deg. F.	Difference in Total Heat per Pound from Ice at t to Water at 32 Deg. $H_{32}-H_t$ B.t.u. per Lb.	$h_{32}-H_t$ B.t.u. per Lb.	Temperature of Water t′ Deg. F.	Difference in Total Heat per Pound from Water at 32 Deg. to Water at t′ h_t-h_{32} B.t.u. per Lb.
—20	23.8	167.2	+ 32	0.0
—18	22.9	166.3	34	2.0
—16	22.1	165.5	36	4.0
—14	21.3	164.7	38	6.0
—12	20.4	163.8	40	8.1
—10	19.6	163.0	42	10.1
— 8	18.7	162.1	44	12.1
— 6	17.9	161.3	46	14.1
— 4	17.0	160.4	48	16.1
— 2	16.1	159.5	50	18.1
0	15.2	158.6	52	20.1
+ 2	14.3	157.7	54	22.1
4	13.4	156.8	56	24.1
6	12.5	155.9	58	26.1
8	11.6	155.0	60	28.1
10	10.7	154.1	62	30.1
12	9.7	153.1	64	32.1
14	8.8	152.2	66	34.1
16	7.8	151.2	68	36.1
18	6.9	150.3	70	38.1
20	5.9	149.3	72	40.1
22	5.0	148.4	74	42.1
24	4.0	147.4	76	44.1
26	3.0	146.4	78	46.1
28	2.0	145.4	80	48.1
30	1.0	144.4	82	50.1
32	0.0	143.4	84	52.1
			86	54.1
			88	56.1
			90	58.0
			95	63.0
			100	68.0

*"Physical Review," 17, p. 193; 1903.

A Monster Aqueduct—The aqueduct conducting the waters of the Owens River, at Los Angeles, is said to be the largest in the world. It is designed to deliver a minimum of 258,000,000 gallons of water daily into the San Fernando reservoir, 25 miles northwest of the city. No pumping plant is required, as the source of supply is several hundred feet above the city. The water will furnish a great amount of power—7000 horsepower is anticipated—for electric lighting and other purposes. The total cost of the water-works will be $25,000,000, and the installation of the power plant will cost approximately $5,000,000 more.—"Exchange."

The Ridgway Steam Turbine

The steam turbine of the Ridgway Dynamo & Engine Co. is of the Rateau type and is built under license from Professor Rateau and C. H. Smoot, of the Rateau-Battu-Smoot Co., the American representatives of the professor. As our readers know from previous descriptions, the Rateau is a pressure-stage turbine, and is shown in conventionalized section in Fig. 2. Steam is expanded through the set of nozzles at the left, impinging upon the bladed wheels *EE*, the engraving showing some of the blades in section. The pressure drop in passing through each set of nozzles is sufficient to generate only a velocity which can be practically abstracted by the single row of buckets upon which the steam impinges in each stage.

With the first few pounds of drop in pressure the velocity generated is great in comparison with the increase of volume, so that a smaller nozzle section is required to pass the same weight of steam. It is not until the lower pressure reaches about 58 per cent. of the higher that the volume begins to increase faster than the rate of flow necessary to take care of it, and the area of the nozzle necessary to pass it increases. As the pressure-drop in the Rateau turbine for the ordinary condition is well within this range, the nozzles are converging. Although the steam expands in going through them, the outlet is smaller than the inlet, as shown in Fig. 2. After having its velocity reduced by passing through the moving blades, the steam is discharging into a second series of nozzles, where it is further expanded, and so on until it is discharged to the condenser. The number of stages required for complete expansion varies inversely as the square of the velocity. If the velocity per stage is to be one-third of that which would be generated by effecting the expansion in a single stage, 9 stages will be required; if one-fourth 16 stages; etc.

Fig. 1 shows this type of turbine, as built by the Ridgway Dynamo & Engine Co., connected with a 375-kw. alternator at the power plant of the Cascade Coal & Coke Co., at Tyler, Penn. This is a mixed-pressure machine designed for high-pressure steam of 125 lb. gage and exhaust steam of 16 lb. absolute pressure and runs at 3600 r.p.m. The low-pressure steam is the exhaust from reciprocating engine units, pumps, etc. By the installation of this unit the capacity of the power plant was increased 66 per cent. without any increase in the boiler plant, and with an actual decrease in the amount of coal consumed over the previous operating condition.

Fig. 3 is a section of the regular high-pressure type.

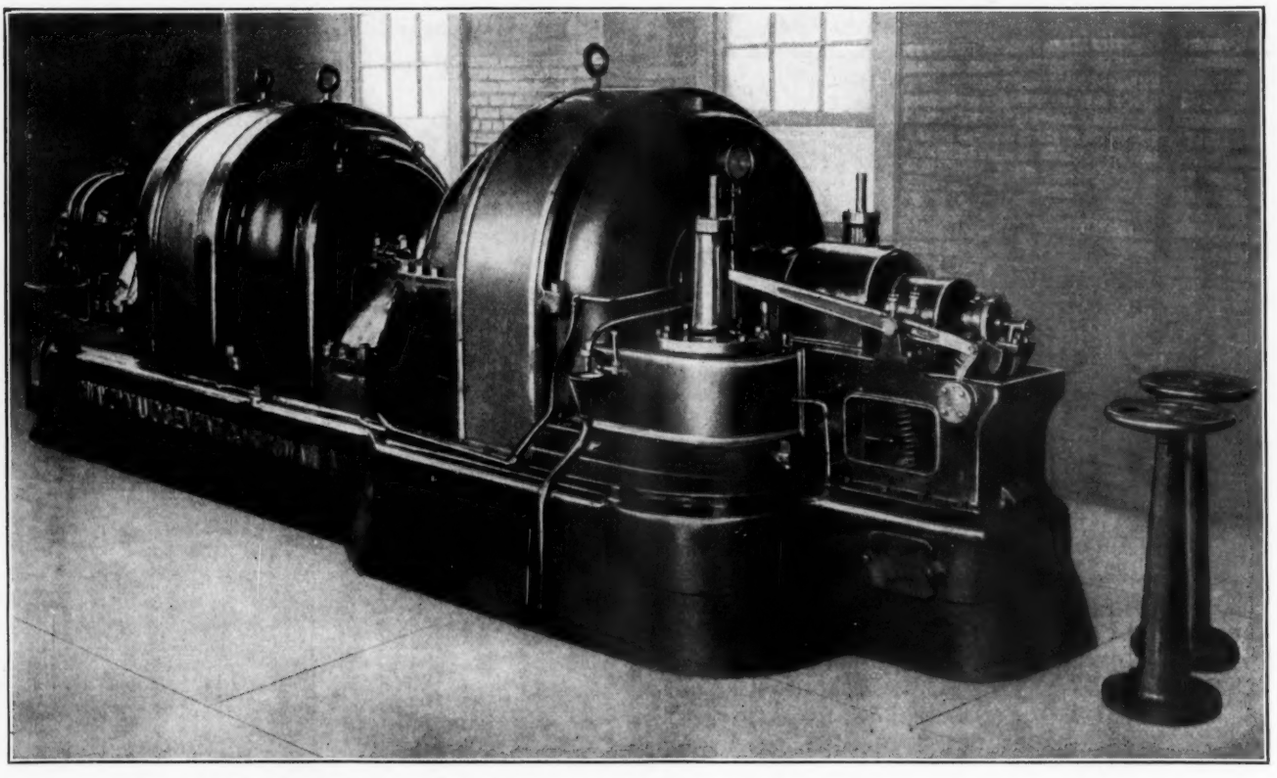


FIG. 1. 375-KW. RIDGWAY TURBO-DRIVEN UNIT AT PLANT OF CASCADE COAL & COKE CO.

Steam enters at *A*, passes through seven sets of nozzles and bladed wheels having passages of ever-increasing section, and is finally discharged into the exhaust passage at the right. There are, therefore, eight different pressures existing in the machine, counting those of the steam chest and the exhaust passage, and the chambers containing these different pressures are divided by heavy partitions. But whatever the pressure in any chamber, it is the same on both sides of the wheel revolving in each chamber, so that, with the symmetrical buckets used, there is no end thrust, and all that is needed to keep the shaft in place and the nozzles and blades in their proper relations are the few thrust rings *RRR* in the bearing of the low-pressure end.

Fig. 3 shows the partitions in section, and it will be seen that they are heavier and more securely packed where

the shaft passes through them, in the case of the high-pressure stages to the left, than in those at the right, where the pressure differences are less.

As the pressure is the same all around the wheel,

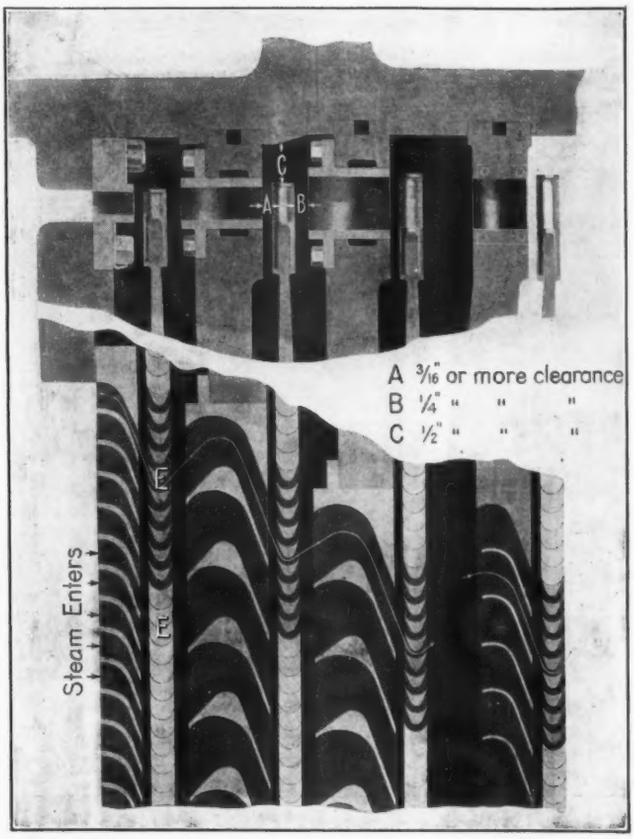


FIG. 2. CONVENTIONALIZED SECTION OF NOZZLE AND BLADING

there is no tendency for the steam to leak by it, and the clearances, both longitudinally, as at *A* and *B* in Fig. 2, and radially, as at *C* in the same figure, may be comfortable and generous, the axial clearance even in small machines being $\frac{3}{16}$ and the radial ½ in. In large turbines these clearances are as much as ⅜ and 1 in., respectively.

The rotating element consists of a high-carbon steel shaft of such diameter that its normal speed is below the critical speed, and on which are turned the thrust rings referred to. The wheels are machined from disks of flange steel, and are keyed upon the shaft, being separated from each other by steel collars which run against the packing in the diaphragms which divide the stages. The buckets are machined from solid bars, the material selected, usually bronze, being adapted to the particular service for which the turbine or stage is designed. They are made in the

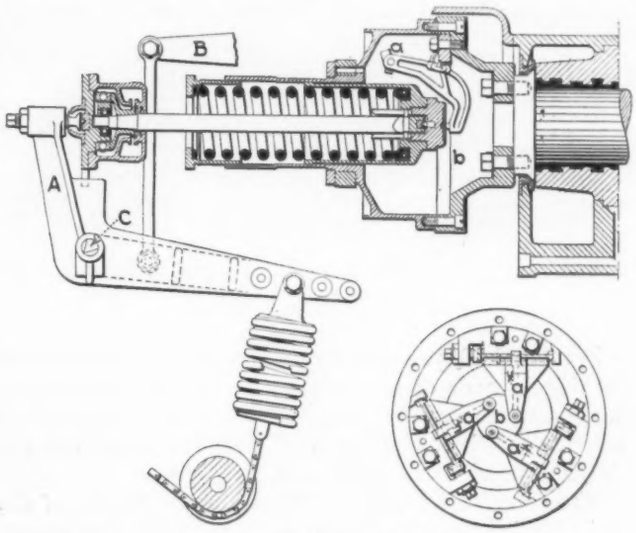


FIG. 4. SECTION AND DETAILS OF GOVERNOR

two styles, Fig. 7, the smaller being secured by rivets through their shanks, so placed as to retain the maximum possible section, the larger with bulb ends which are driven into slots in the periphery of the wheel and peened solidly into place. Each bucket of either type carries its own shroud and, when assembled in the wheel, is in rigid contact at its outer end with the adjacent bucket, affording mutual support against vibration and damage.

The casing, the heads, and the diaphragms which separate the stages, are split horizontally, the top halves of the diaphragms being attached to the upper half of the

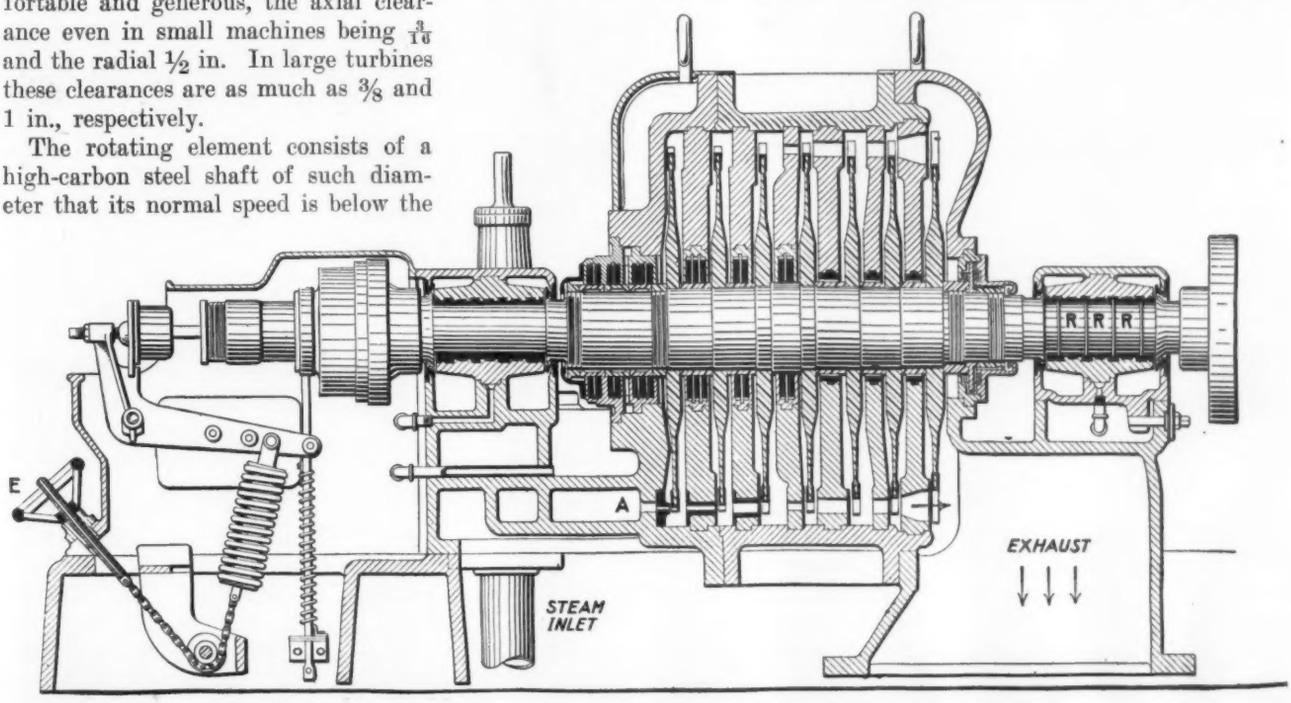


FIG. 3. LONGITUDINAL SECTION RIDGWAY-RATEAU STEAM TURBINE

casing and lifting with it. The steam and exhaust connections are made to the lower half, so that they need not be disturbed when the turbine is opened. The nozzles with small area for the initial stages are machined castings bolted into place, as shown in Fig. 5. In the later stages the blades forming the nozzles are cast in place in the diaphragm and extend all or part way around its periphery, as shown in Figs. 6 and 7.

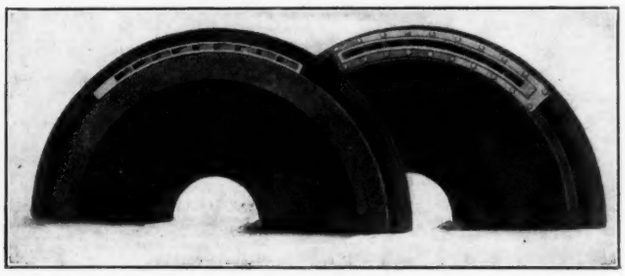


FIG. 5. CAST NOZZLES

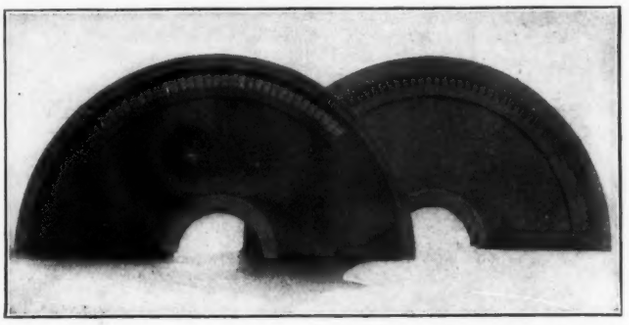


FIG. 6. CAST-IN NOZZLES

For the high-pressure boxes and the diaphragms the packing is made of carbon blocks. For the low-pressure boxes a water impeller is used, so arranged that it does not prevent the adjusting of the clearance between the stationary and revolving elements.

The governor is mounted directly upon the end of the main turbine shaft, as shown in Fig. 3. It is shown more in detail in Fig. 4. The actuating weights consist of the longer arms *a*, of three bell-crank levers fulcrumed upon tool-steel knife-edges, the relative location of which is shown in the detail drawing in the lower right-hand corner, the parts being similarly lettered. The small projections shown at the end of the lever in the section are buffers. As the weights fly outward the member *b*, upon which the other arm of the bell crank presses through tool-steel cup points, is moved to the left against the tension of the spring, turning the larger bell crank *A* around the fulcrum *C* and communicating its movement to the throttle valve through the lever *B*. Additional tension may be put upon the governor through the handwheel *E*, in Fig. 3. The thrust which is interposed between the flyball governor and the valve gear is provided with two ball bearings to take the direct thrust as well as any side thrust due to lack of perfect balance. The usual auxiliary governor, which shuts the turbine down automatically when the speed exceeds a predetermined limit, is included. The bearing lubrication is by the gravity-pressure system with circulating pump, filter and cooler, or by ring oiling with water-cooled bearings.

The turbo-alternator, also made by the Ridgway company, is of the revolving-field type, with radial slots for the field coils. In the process of stacking the core numerous air ducts are provided, insuring a more thorough ventilation than is possible with a solid core. Generous ventilating ducts are also provided in the stator, and an outside lagging directs the heated air to an outlet at the bottom. Direct-current turbo-generators are carried directly upon the turbine shaft without the interposition of gearing, the strength necessary to resist the high centrifugal force being secured by holding the winding which is made of bar copper wedged into the slot by heavy bronze rings.

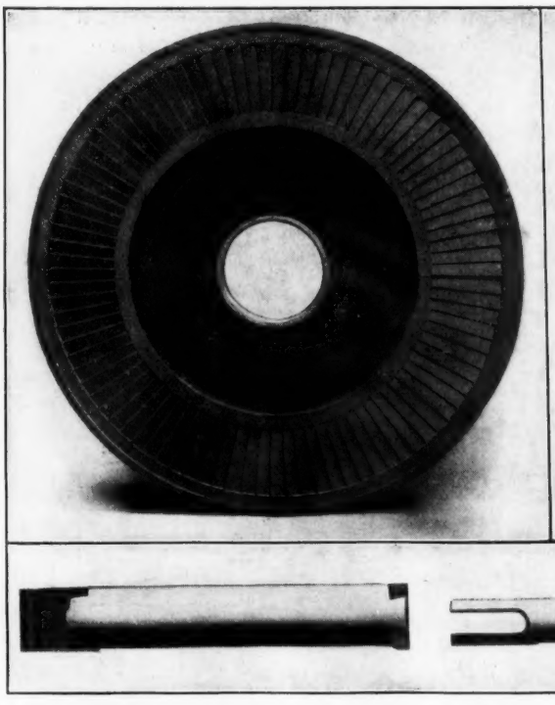


FIG. 7. FULL PERIPHERAL NOZZLE

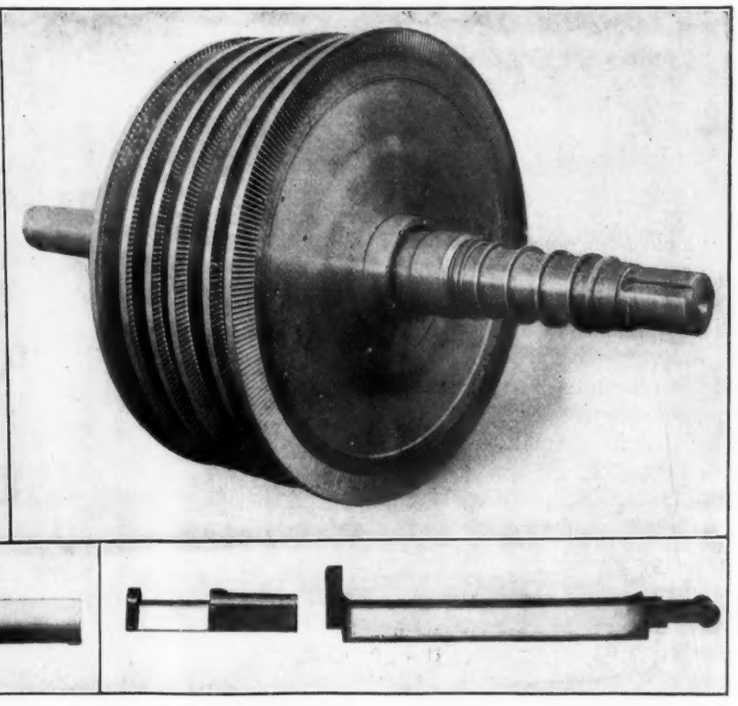


FIG. 8. FULL SET OF MOVING BLADES

Simplex Condensation Meter

This meter, Fig. 1, is designed for the measurement of steam used in buildings heated from an outside source, by weighing the water of condensation. It can also be used for measuring various liquids where a gravity discharge permits, but it will not operate under pressure.

The meter consists essentially of a tilting copper bucket which measures the condensation. When sufficient water

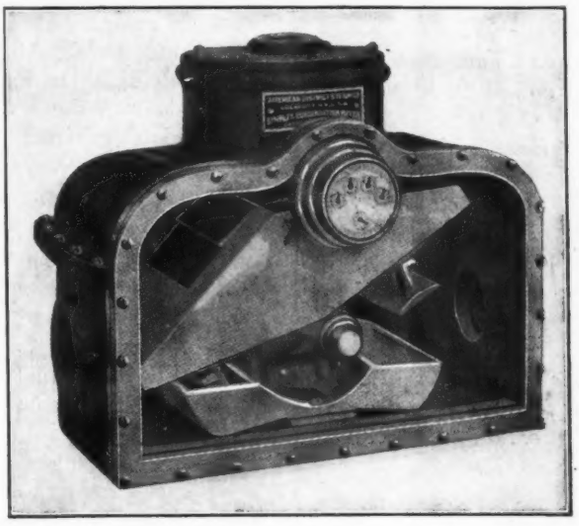


FIG. 1. INTERIOR OF THE SIMPLEX CONDENSATION METER

has run into one side to overbalance it, the bucket tilts, discharging the contents into the meter case, and then through the outlet pipe to the return system or to the sewer. In tilting, the empty side is brought to the filling position. The tilting action is repeated until water ceases to flow to the meter.

The bucket is mounted on a shaft that is supported on roller or ball bearings on the outside of the meter case. In the bottom of the case are dashpots which remain

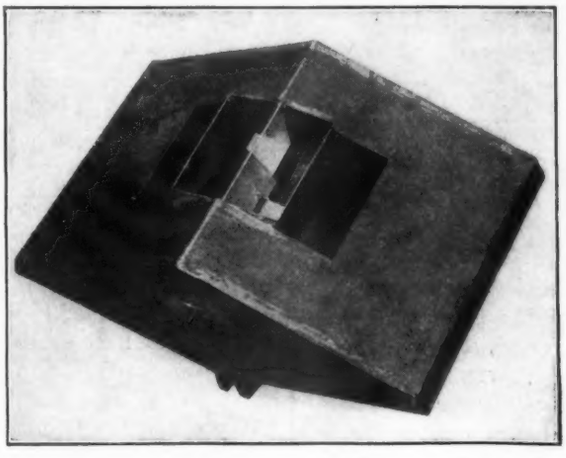


FIG. 2. AUXILIARY BUCKET IN TILTING BUCKET

filled with water and serve as cushions to prevent objectionable noises in the operation. A recording dial indicates the number of pounds of water that have passed through the meter.

To prevent waste of condensation when the tilting occurs, an auxiliary bucket has been arranged to catch the water discharging from the inlet nozzle. This is shown in Figs. 2 and 3. Referring to Fig. 2, the open spaces in the main bucket are for the inlet nozzle to discharge into the empty half. The auxiliary is made with two sections, each discharging to opposite sides of the main tilting bucket, which, when one side contains a certain height of water, starts to tilt to the discharge position.

Fig. 3 shows the operation of the auxiliary in catching the water which would otherwise be wasted between the point of beginning of the bucket dump and the time when the center partition of the main bucket passes under the nozzle. During this period the water is diverted to the empty side.

The auxiliary bucket cannot cut off the total amount of water which would be discharged during the complete tilting movement. It does, however, intercept a large percentage of this waste. Referring to Fig. 3, the heavy arrows marked *A* indicate the bulk of water entering the main bucket. As soon as this has received its full quota of water, it tilts and discharges, and at that instant the edge of the auxiliary bucket passes under the nozzle opening and the water passes into it, as shown by the arrows *B*, thence through a hole in the middle partition to the other side of the bucket, where it is received and weighed on the next discharge. The operation when getting under way for discharging is necessarily slow, and while gather-

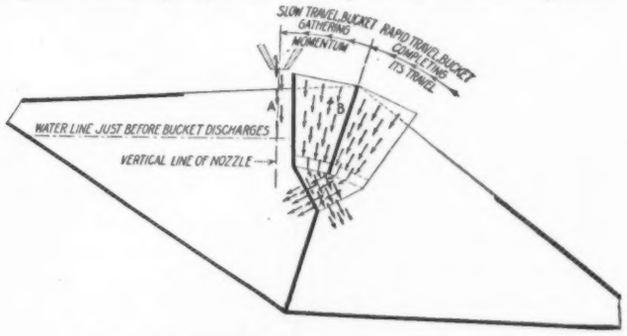


FIG. 3. DIAGRAM OF THE TILTING BUCKET

ing momentum the auxiliary bucket cuts off the water. After the bucket has acquired momentum and is traveling at a rapid velocity, only a small amount is wasted, owing to the fact that it passes over to the other half of the auxiliary and back into the side which has already discharged.

Tests of these meters show that this very simple device, which requires no actuating mechanism, takes up and records the bulk of the waste water which would otherwise have entered the bucket after it had started to dump, and for which, previously, corrections had to be made in the testing.

This meter is manufactured by the American District Steam Co., North Tonawanda, N. Y.

⁂

Steam Separators with receivers of liberal proportions should be used near engines, to provide a reservoir of steam near-by and to minimize pulsations in the lines.

⁂

An Experience in Seeking Help, cited by Charles T. Porter in his "Engineering Reminiscences," is more typical of former times than the present.

"I called upon a friend who was a great mathematician and the editor of a series of mathematical books then largely used, and stated my trouble in calculating the centrifugal force and momentum as applied to my governor. He illuminated the subject to me as follows: 'You seem to be a persevering young man; keep hard at it and you will solve the difficulty by and by.'"

The Uniflow Steam Engine

The fact is established, not only by numerous and repeated tests, but by everyday practice, that the uniflow engine requires only about the same amount of steam as a compound engine. There are others besides our correspondent who cannot see how this can be. Here is one way of accounting for it.

A 100-per cent. engine, i.e., an engine that could turn into work all the heat set free by working steam between 150 lb gage, 100 deg. superheat, and atmospheric pressure, would run on about 13½ lb. of steam per hour per i.hp. The best actual engines require 17 or 18 lb.

If an engine used 18 lb. per hp.-hr., it would develop $^1/_{18}$ of a hp.-hr. per pound of steam. A horsepower-hour is equivalent to 2544.65 B.t.u. Hence, the engine converts

$$2544.65 \div 18 = 141.4$$

of the 1252 B.t.u. which is brought into it with each pound of steam into work.

If the engine had no losses it could run on 13.5 lb. per i.hp.-hr., and convert

$$2544.65 \div 13.5 = 188.5$$

B.t.u.

What becomes of the difference between this and the 141.4 B.t.u. converted by the best actual engines and the much less converted by the less efficient types?

The heat which is carried into the engine cylinder by the steam can get out in only three ways:

Radiation;

Conversion to work;

In the exhaust.

And it has got to get out as fast as it goes in, or it will accumulate in the cylinder and melt it down.

The radiation loss from a well lagged cylinder is trifling. It is evident that most of the unutilized heat escapes in the exhaust.

How does it get there?

It is absorbed by the containing surfaces, the cylinder walls, port surfaces, cylinder, and piston heads when the steam is hotter than they are, i.e., through a large part of the forward stroke, and given out to the exhausting steam throughout the entire return stroke, or until, by compression, the temperature of the inclosed steam equals that of the walls.

Whatever goes to nullify or to discourage this transfer of heat between the working medium and the containing surfaces, tends to reduce this bypassing of the heat from the hot to the cold side, from the steam chest to the exhaust, without doing work, and hence tends to increase the efficiency of the engine.

Suppose a cylinder could be so thoroughly jacketed on heads and on barrel with steam so hot that the inside skin of the containing surfaces would be as hot as the entering steam. When the steam came in it would remain in a vaporous or gaseous condition, instead of some 20 per cent. condensing upon the cooler iron, as in the usual case, and it would retain its initial condition until cutoff occurred and expansion commenced. Then it would commence to cool and to absorb heat from the containing surfaces. Perhaps it has some superheat in its initial condition, so that it will not commence to condense immediately, or until the temperature has been reduced by expansion enough to use the superheat all up.

Superheated steam, dry steam, is a very poor absorber of heat. The heat from the cylinder head can radiate or "shine" through it, as the heat from the sun can radiate through the air without warming it up much. It is only when the sun shines on the rocks, and other substances which will readily absorb its heat, and then the air passes over them and picks the heat up by convection, that we get an energetic heating effect. The mere shining of the sun through the air heats it but little, as witness the temperature at elevations where there is little solid material, as compared with the exposure, to absorb and radiate the heat.

An incredulous correspondent writes:

I studied with interest the article under this heading in POWER *of Nov. 17, and as I have written before in regard to this engine, I do not see how it can show good economy.*

Regardless of the test data given (which are undoubtedly correct figures), there remains much that should be explained. Take the figures on page 702 in regard to compression; it is found that with 26-in. vacuum there will be about 38 lb. compression with a clearance of 5 per cent. This does not seem so bad at first thought, but it is bad, for figuring along the same line, I find that at half stroke there is a back pressure of 18 lb.—3.3 lb. above atmosphere. Imagine producing a 26-in. vacuum for an engine that is in direct connection with it for only $\frac{1}{10}$ stroke, and at half stroke is exhausting or, what is of the same effect, has a back pressure over 3 lb. higher than it would have running noncondensing! In the several articles I have seen regarding this engine, the claim is made that the exhaust steam not returning through the cylinder keeps a more even and hotter temperature. So far, in my experience it never has been explained to me why steam is hotter at a given pressure traveling in one direction than in some other. If the engine exhausts down to 2 lb. the temperature will be around 126 degrees, regardless of whether it departs by the back or front entrance. If not, why not? Then again, there is some condensation in any steam cylinder and, as is well known, this portion of the impulse charge sticks more or less to cylinder walls and, in general, lags behind the portion that remains steam. Then it would seem that a large percentage of this near water will not get out of the exhaust, but will remain to be compressed, for that $\frac{9}{10}$ of stroke in the uniflow cylinder. Perhaps this tends to high economy. If so, why?

I note this particular engine has steam jackets. This, of course, will increase the economy of any type of cylinder, but down home it is the custom to take the cost of maintaining this steam jacket. This takes us sort of back to the coal heap, which, after all, is the item that most interests us of the monkey-wrench and overalls. We do not write for argument, we wish to learn. That is why we take POWER. *So, if the editor and the higher professors will bear with us and show us just how some nice things are done and why, we will be truly thankful.*

Under these conditions it can readily be conceived that even after the expansion has proceeded until the steam is below the saturation point, or even if there is initial condensation, the film in immediate contact with the hot surfaces gets dried out and superheated. Then the absorption of heat from the surfaces stops or becomes very slow.

The effect is analogous to that produced when a stratum of air gets around the cooling surface in a condenser, or when, in a boiler with poor circulation, the steam does not get readily away from the heating surface, or when, in a high vertical radiator, an inside pipe is so smothered that the already heated air hugs it instead of getting away and allowing other and cooler air to come up and be heated. So long, in the case of the engine, as this blanket of highly heated steam can be kept against the hot surfaces, there will be little transfer of heat to the contents of the cylinder, to be carried off in the exhaust.

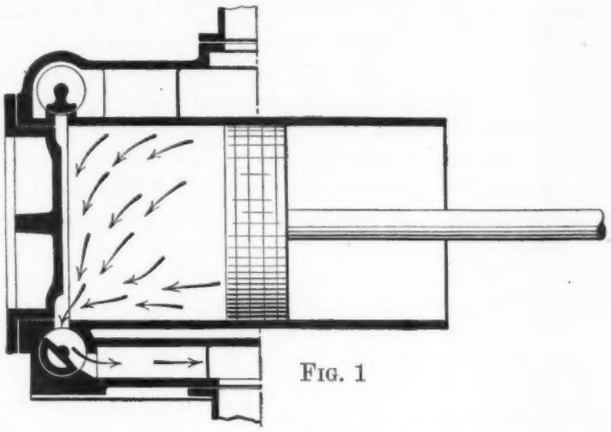


FIG. 1

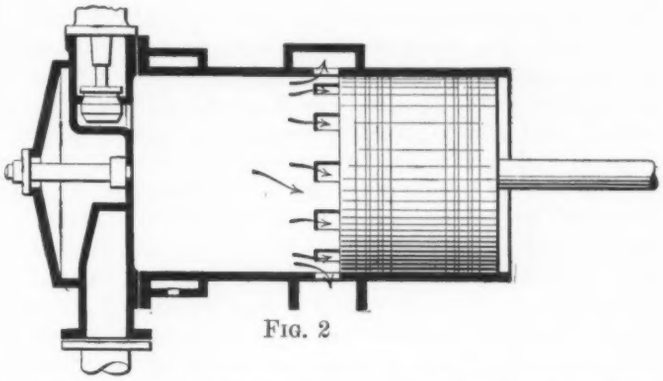


FIG. 2

Now, in the case of the counter-flow, or usual, type of engine, where the exhaust and the steam valves are both at the same end of the stroke, there comes, when the release occurs, an immediate rush of the steam backward toward the hot head, in a struggle to get out at the open exhaust port, as shown in Fig. 1. This steam, even if it were superheated to start with, has become cool and moist by expansion and the conversion, with consequent condensation, of more of its heat into work than it could spare and remain dry. The protecting blanket of superheated steam is swept away from the hot surfaces of the entering end, and the cold wet steam impinging upon these surfaces absorbs heat from them by evaporation and convection to be carried uselessly into the exhaust or to make more work for the condenser. In a single-valve engine, where the same port is used for inlet and exhaust, even the surfaces of the port through which the hot entering steam must come are washed and cooled by this heat-absorbing mixture of low-pressure steam and water.

With the uniflow, or central-exhaust, engine, Fig. 2, there occurs no such reversal of flow. When the piston passes over the central port the steam is released from that end of the cylinder, the hotter steam at the head or jacketed end simply expanding and pushing the cooler wetter steam before it. The protective blanket on the cylinder head and the hot end of the cylinder is not swept off, but remains intact, and all the heat which is carried to the exhaust is that which the steam in the exhaust end of the cylinder can pick up in sweeping over the cooler piston head and the walls near the exhaust port, as it is pushed out of that port by the expansion of the rest of the steam from the pressure at release to that of the exhaust or condenser, and by the backward movement of the piston up to the point where it again covers the central port—usually about one-tenth of the stroke. When the exhaust port is covered there is the volume of the return stroke yet to be completed, plus the clearance volume, full of steam of the exhaust pressure; that near the piston probably at a temperature corresponding to its pressure, that in contact with the hot head superheated considerably above that temperature. As the compression proceeds the temperature rises with the pressure, and there will be some condensation against the piston head, which is now absorbing heat that will be carried off in the next outrush of exhaust, but when the compression stroke is completed the clearance will be full of steam of practically the initial pressure, the cylinder head and clearance surfaces will be good and hot and the piston head as hot as it could get by taking heat from the compressing steam, so that the entering steam is received upon surfaces of about its own temperature and initial condensation much reduced.

Our correspondent, in saying that he would not care to maintain a condenser which was in communication with the cylinder for only one-tenth of the stroke, loses sight of the fact that the diminution in the back pressure endures throughout the stroke by reason of the lower initial compression pressure. Fig. 3 will make this plain. The full line represents the counter-pressure running noncondensing, the dotted line condensing, the exhaust port closing when the return stroke is one-tenth completed in both cases. The diagram ought also to make plain to our correspondent that the method by which he computed the absolute back pressure at half stroke to be 18 lb. absolute has something the matter with it. The steam used in the jackets is included in the steam rates reported.

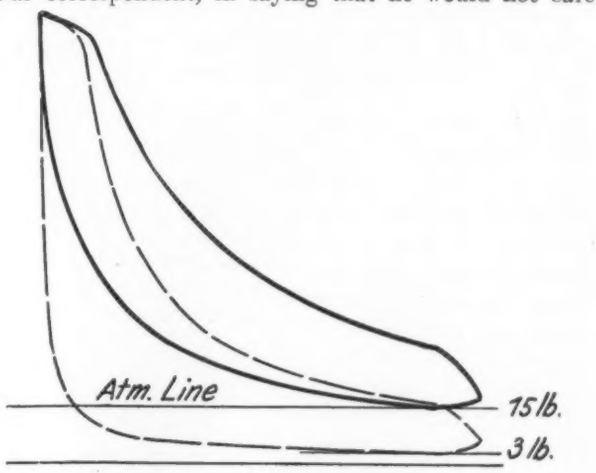


FIG. 3

Electric-Motor Noises

By Francis H. Davies

SYNOPSIS—Motor noises classified as to the nature of their causes—namely, magnetic, ventilating, and mechanical. How to detect the cause and the remedy to be applied.

Primarily, the noises arising from the operation of any machine may be divided into two classes—those directly transmitted by the air and those transmitted through the ground and walls. Air-transmitted noises may arise from several causes, but in the case of electric motors they are usually magnetic, being due to vibration of armature teeth and laminated pole shoes under a high-frequency alternating field. Such noises are characterized by a penetrating hum or shriek and are difficult to cure. Their intensity depends upon the field strength, the frequency of reversal, the form of the core and pole stampings, and the manner in which these are put together. Designers appreciate the importance of reducing magnetically generated noises to a minimum, and the following points out what experience has proved necessary to this end.

Magnetic Noises

It is inadvisable that the pitch of the armature slots at the circumference exceed $\frac{5}{8}$ in., as it is found that wide and open slots produce oscillations of the field flux which, acting on the laminations, cause vibration and consequent noise. Where the slots are wide, iron wedges may be inserted, the action of which is to spread out the flux and allow the teeth to enter and leave the field more gradually. The same effect is secured in many armatures by slanting the slots instead of arranging them parallel with the shaft axis; and, with a similar object, pole shoes are sometimes constructed with their horns on the slant as shown in Fig. 1, which allows the core teeth to enter and leave the field gradually. A noisy machine may sometimes be cured by this alteration to the poles, which is comparatively simple provided the poles are of the solid and not the laminated class. It is generally understood that for noiseless running the polar horns should be well rounded and tangential to the armature (Fig. 2) instead of embracing it closely at the tips, the object being to reduce the intensity of the field at the extremities.

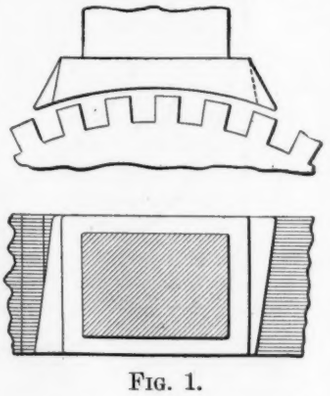


Fig. 1.

Weakening the field by increasing the air gap is another method of minimizing magnetic noise, but this results in a higher speed for an equal output.

Laminated poles are certain to give rise to noise unless the laminæ are so tightly built up that vibration is impossible. Furthermore, the rivets securing the laminations must be as close as possible to the outer edges, particularly those passing through the horns, as this will render them less liable to vibration arising from the rapidly changing density of the magnetic flux as the teeth of the armature core pass the horns. This effect is at a maximum when the number of slots in the armature core is small, because then the magnetic disturbance will be greatest. Therefore, the designer allows for as many slots as possible, taking care also that they are so pitched that one does not leave the pole at the same time as another arrives under it; such spacing will cause maximum swinging of the flux and consequent noise. In other words, the length of the pole face measured on the arc should not be a multiple of the slot pitch.

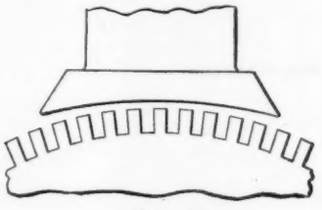


Fig. 2.

Ventilating Noises

Second to magnetically generated noises are those arising from the ventilating arrangements. The churning of the air by revolving parts and its flow at high velocity through the end-shield openings set up a deep noise comparable to that of a fan. It is not very objectionable, but may be lessened by partially closing the vents in the end shields, although this interferes to some extent with the ventilation. It is important that there be as few projecting parts as possible in both the field and armature as these act as vanes and propellers.

A more objectionable noise is that caused by air passing at high speed through ventilating ducts. It is often difficult to distinguish this from magnetic noises. This point may be settled, however, by running the machine up to speed and then switching off the current. It is always possible to modify ventilation noises by reducing the speed, and in some cases a small reduction will be effective.

Mechanical Noises

Noises arising from mechanical causes are usually attributable to faulty design, poor workmanship, or wear. An armature that is out of balance will set up heavy vibrations and an annoying sound that will travel some distance through the framework or walls of the building, unless special steps are taken to isolate the machine. Bearing wear, also, will result in an armature losing its true concentric position with regard to the poles, and this sometimes causes a heavy knock. The remedy for an unbalanced armature is, obviously, to balance it carefully, noting whether it is a case of a sprung shaft and not an original fault, or if the bearings are worn and require replacement. When the bearings are in good condition and it is found that the armature is not truly concentric with the fields owing to bad assembling, this can often be rectified by the insertion of liners or their withdrawal from between the poles and the yoke ring, unless the field be one solid casting. In the latter case liners can sometimes be placed under the bearing pedestals.

Another likely cause of knocking is a loose part, and it

is often necessary to overhaul the machine thoroughly in order to locate it. Motors working under arduous conditions of frequent reversal are apt to develop a loose armature core owing to wear of the keyway.

It is well known that sound is carried by solid bodies better than by air; consequently, a noisy motor may cause annoyance at a considerable distance, particularly in the case of buildings of steel structure. In such cases the only remedy is to isolate the machine from the floor, wall or ceiling upon which it is fixed. There are numerous ways of doing this, one particularly good one being the placing of felt under the bedplate, with washers of a similar material inserted under the heads of the holding-down bolts. It is also well to bush the holes in the bedplate with similar felt, for if the bolts touch anywhere they will act as conductors. It should be borne in mind that felt of the ordinary type, such as that used for roofing, is quite useless and cannot long retain any sound- or vibration-absorbing properties that it may originally possess. Special felts are made for this purpose, sometimes with cork and rubber inserts.

Minor Noises

Among the minor noises are those arising from the commutator and brushes. A high bar in the commutator is a not infrequent cause, but the hissing common with many motors is due to the brushes being either too hard, improperly bedded, tight in the boxes, or adjusted at the wrong tension. These faults are easily located and call for only obvious remedies. The motor itself is not always the greatest sinner, and a noisy installation may often be quieted by proper attention to the belting or other form of transmission used. The flapping of a slack belt is easily remedied, though the noise set up by a slipping belt may require more drastic treatment. Should the slip be due to overload a larger belt and, perhaps, larger pulleys must be provided; or if it arises from too small an arc of contact the centers must be increased or an idler pulley employed.

There are also, of course, the usual remedies of wooden or paper pulleys and various dressings having for their object better adhesion of the belt to the pulley. For quiet operation belts should not be run against the joints and metallic fasteners should not be broader than the belt nor project through to the running side. Where chain drives of the "noiseless" type are installed proper attention is all that is required to enable them to justify their name. If, however, they are not properly erected and are allowed to become too worn, dirty and dry, a certain amount of noise is inevitable. Spur gearing is a type of transmission which frequently gives rise to much noise, and for the best results the wheels must be truly cut, well lubricated and correctly distanced. The last is especially important, for if the wheels engage too closely or are too far apart they will cause objectionable noise. Fiber, paper and rawhide pinions are to be recommended and provide the best solution of the problem of quiet spur gearing.

Loop, Ring and Duplicate Steam-Pipe Systems should be indulged in sparingly, especially if much extra length of pipe is involved, or should be so arranged that unused sections can be shut off. This applies, of course, to exaggerated and complicated systems designed to meet every possible contingency. There can be no objection to a complete loop where the boilers and engines are set practically parallel to each other, so that the headers may easily be connected at each end.

JUST FOR FUN

New Commutator Lubricant

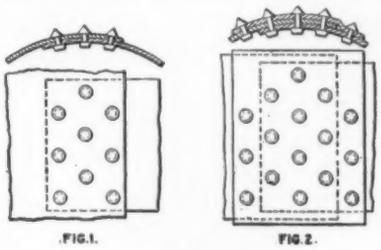
To a young man was assigned the duty of caring for the motor in a small manufacturing concern. It had been the custom to rub the commutator with a cloth dampened with thin oil after the power had been shut off, while the armature was still rotating. One evening the swab cloth was missing, but a bottle of shellac and a cloth were handy, so he used that on the commutator. In the morning the motor refused to start at all, and an inspector was sent for. He found a finely polished commutator, but the brushes were all stuck tight and had to be pried loose.—*R. A. Cultra, Cambridge, Mass.*

A Parallelism Indicator

A glass company in western Pennsylvania had five vertical gas engines of about 600 hp. installed, but brought suit against the builders, claiming that the engines were not as guaranteed. We have one of the same kind, running with the generator in parallel on a 23,000-volt high-tension line. The engine builders and the glass-company officials visited our plant to see the engine and get our reports. After we had explained that the generator was operated in parallel with the main plant about 100 miles away, one of the glass-company officials watched the make-and-break igniters working, and then asked the engineer if the engine was in parallel every time the thing clicked.—*R. G. Curren, Jr., Kittanning, Penn.*

An Improved (?) Boiler Joint

Fig. 1 shows the original longitudinal triple-riveted joint on the shell of a boiler, with an efficiency of 76.5 per cent. The Chief Engineer (?) wanted to have a higher working steam pressure in the plant than he was carrying. He had heard of boiler joints being made stronger by having a cover strap and two additional rows of rivets put in, so he got busy and ordered the change made on his boilers.



Attempt at Strengthening Joint

He cut out all rivets from the original joint and had a cover strap fitted. He had one row of rivets added on each side, as shown, Fig. 2. After all the inconvenience and cost of labor due to this change, he was informed the joint had exactly the same efficiency as before.

The weak point of the original joint was the net section of plate between the outer rows of rivets. In his change he added one row of rivets on each side of the original, but spaced them the same distance apart as the first three rows were. The three center rows were changed from single to double shear, but there still remained the two outer rows in single shear, and the net section between the outer rows had the same value as in the original joint. Therefore the joint efficiency was the same.

If this fellow had asked for proper advice he could have been put right and saved dollars for his company and trouble for himself. The boilers are still in use, but at no higher pressure.—*J. A. Sawyer, Phila., Penn.*

CO_2 and the Character of Fuel

By T. H. Reardon

A high percentage of CO_2 in uptake gases indicates in a general way a high degree of efficiency in the process of combustion, but it may not be so generally known that an increase or decrease in this gas indicates the character of the coal or fuel.

Theoretically perfect combustion is impossible whether conducted with laboratory refinement or with boiler-room methods. By perfect combustion it is understood that the agents that enter into the reaction are present in quantities necessary to yield the final products of combustion with no excess of any reacting element. It is clear that if a sample of pure carbon could be burned to completeness with the theoretically necessary quantity of oxygen, the sole product of combustion would be CO_2 and the percentage of this compound in the combustion products would be 100. Further, if a sample of fuel consisting of both carbon and hydrogen were burned under the same conditions the products of combustion would be CO_2 and water, and if a sample of these products were drawn into an aspirator for subsequent titration with caustic potash it would be found that the water present as aqueous vapor in the condition of superheated steam, would condense, its volume becoming practically nil. This removes it from the sample, leaving only CO_2 as the gas that later will be drawn into the burrette for measurement.

When combustion is supported with the theoretically necessary quantity of air, certain differences will be apparent. Air consists of a mechanical mixture of oxygen and nitrogen, the proportions by volume being usually taken as, oxygen, 21 per cent.; nitrogen, 79 per cent. If the complete combustion of carbon could be carried out with the theoretically necessary quantity of air, the percentage of CO_2 in the stack gases would be the same as that of oxygen in the air, viz., 21 per cent. This is a limiting high mark obtainable only with ideal conditions and with a combustible consisting entirely of carbon.

As soon as experiments are made with a fuel consisting of a mixture of carbon and hydrogen, the percentage of CO_2 in the products of combustion will diminish, even with perfection in the processes.

Carbon unites with oxygen according to the equation

$$C + O_2 = CO_2; 12 + 32 = 44.$$

Hydrogen unites in a similar way with oxygen as follows:

$$2\ H_2 + O_2 = 2\ H_2O; 4 + 32 = 36.$$

An inspection of the equations shows that 12 parts by weight of carbon require 32 parts by weight of oxygen for perfect combustion, or 1 part by weight of carbon requires 2⅔ parts of oxygen. For hydrogen we find that 2 parts by weight require 16 parts by weight of oxygen, or 1 part hydrogen requires 8 parts of oxygen. The weights and volumes of air required for carbon comsumption and for hydrogen, respectively, are in the same proportion, i.e., weights being equal, hydrogen requires three times as much oxygen or air for its combustion as carbon does.

Each per cent. of hydrogen content in the fuel, therefore, reduces the percentage of CO_2 0.21 per cent., because in combustion hydrogen yields no CO_2 and dilutes the stack gases by introducing three times as much inert nitrogen as would accompany the oxygen used in case the hydrogen content of the fuel had been carbon.

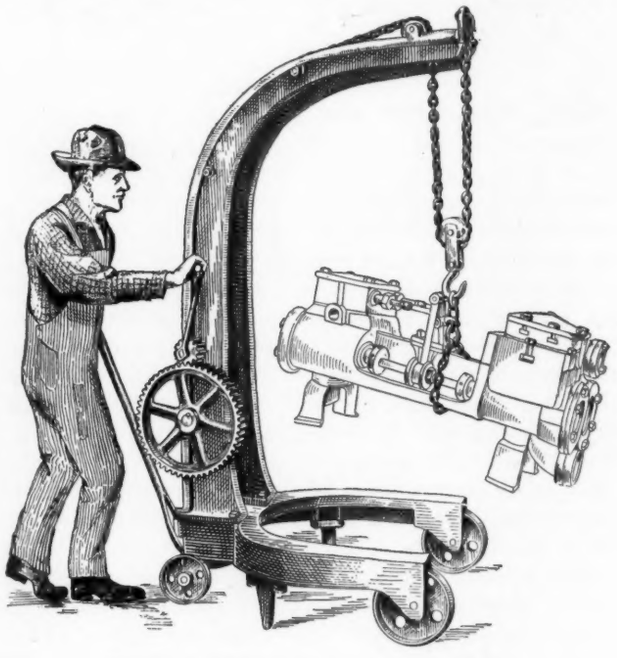
It is obvious that as hydrogen increases in amount in the fuel the percentage of CO_2 must diminish, and that if the hydrogen became equal to 100 per cent., the percentage of CO_2 would be 0.

A study of this subject is interesting, and will materially aid in making clear the significance of CO_2 in the stack gases and the extent to which its presence is influenced by various factors.

Canton Portable Floor Crane and Hoist

Engineers will find the Canton portable floor crane and hoist a convenient, and in some plants a necessary appliance for handling heavy work which would require several men and much time to perform by hand.

The crane bed is fitted with two rear-bearing and two



Portable Floor Crane and Hoist

guide wheels. The latter are provided with a tongue so that the tool can be pulled from one part of the plant to another, the same as if the load were on an ordinary truck. The crane arm and its windlass are bolted to the body.

In the engine room the contrivance will be found convenient for handling cylinder heads, heavy pillar-block caps, steam pumps or any other apparatus which would require jacking, especially where an overhead crane is not available.

This hoist is manufactured by the Canton Foundry & Machine Co., Canton, Ohio.

A Fine Engine-Room Performance—The sinking of the German cruiser "Nürnberg" by the British cruiser "Kent," in the action off the Falkland Islands, was due, primarily, to the remarkable work done by the engine-room and stoke-hole staffs of the "Kent." The trial speed of the "Kent," which was an eleven-year-old ship, was 22½ knots, and it looked as though her attempt to overtake the 23½-knot "Nürnberg" would be fruitless. But in response to the captain's appeal, the engineering force managed to push the speed up to 24 knots per hour, or one knot more than the ship had ever steamed since she first went into commission, and gradually she overhauled and got within range of the enemy.—"Scientific American."

A Brief History of the Thermometer

By W. S. Atchison

In looking at a thermometer—apparently a glass tube containing either quicksilver or a colored liquid and having some sort of a scale—one is not apt to realize the thought, skill and research it has taken to bring this simple, yet universally necessary article to its present state. For many centuries scientists have worked in an endeavor to perfect it, but only during the past forty years have they found out all the details necessary to the manufacture of a more or less perfect article.

Many people are credited with the invention of the thermometer, Drebble, a Hollander, being referred to more than any other; but to Galileo Galilei the laurels should probably be handed. According to history it seems that about 1592 he invented at Padua an instrument described as "a glass containing air and water, to indicate changes and differences in temperature."

With the idea started, the Grand Duke of Tuscany investigated this invention and improved it more or less between 1630 and 1640. The original thermometer consisted of a glass tube about 16 inches long with a hollow ball, or bulb, at the end. The whole was heated until the air inside became rarefied, when the open end was placed in water, the tube being kept upright. As the air in the tube cooled or contracted, the fluid (water was originally used) rose to a certain point and any subsequent changes caused the level of the fluid to be either elevated or depressed.

This was used by Sanctorius as a "heat measure," or fever thermometer. It is on record that he had his patients hold the top of the thermometer so the level of the fluid would be arrested at a point equal to the temperature of the person holding it. A point was undoubtedly determined by a normal, healthy person beforehand, and it is reasonable to assume that Sanctorius drew his deductions by noting the distance above or below this "normally healthy" person.

Before ten years had passed the Grand Duke of Tuscany had carried out his idea of first partly filling the tube with alcohol and closing the open end, thus sealing it and excluding the air. Realizing that the level of the liquids in these various instruments meant nothing, pupils of Galileo sought to make a scale of temperature and melted onto the tube of their thermometers small glass balls about the size of a pin's head, the zero of the scale being the point to which the liquid fell in a freezing mixture of salt and water.

At one time the bright minds of Europe decided that the freezing point of liquids varied to such an extent that it could not be used as a test point, and suggested taking the temperature in a cave cut straight into the bottom of a cliff fronting the sea to the depth of 130 ft., with 80 ft. of earth about it.

About 1662 Hooke, placing his instrument in freezing distilled water, marked "zero" at the top of the column of spirit after immersion of the bulb. Soon after this he suggested that the second point should be the boiling point of water, but this was not adopted at the time. Delance suggested that the freezing point of water should be marked "cold" (—10 deg.) the melting point of butter "hot" (+10 deg.) and the space midway between "temperate" (0 deg.), with ten divisions between each.

In 1714 Fahrenheit arranged a scale for thermometers that showed the freezing of water at 32 deg. and the boiling of water at 212 deg. Many suggestions have been made as to why he graduated the freezing and boiling of water into 180 divisions, one being that as he was an astronomical-instrument maker and as his machines divided to full circles (360 divisions), he used a half-circle for his scale. Seventeen years later Réaumur, a French physicist, brought out a scale on which the freezing point of water appeared as 0 deg., the distance between this and the boiling point of water being divided into eighty equal parts. Anders Celsius, professor of astronomy at the University of Upsala, proposed a scale in 1742 and called the freezing point of water 100 deg. and the boiling point of water zero degrees.

These points were afterward reversed by Christin of Lyons (France) in 1843, and the result is the well-known Centigrade scale. Athanasius Kircher was the first to use quicksilver in thermometers. Quicksilver and alcohol have been accepted by the scientific world as convenient and accurate means to indicate the temperature of anything with which the tube containing them may come in contact.

For high temperatures quicksilver is used, as it freezes at about —38 deg. F. (—39 deg. C.) and boils at 662 deg. F. (+357 deg. C.). As the freezing point of mercury is fairly high, alcohol thermometers are invariably used in very cold climates. This liquid freezes at —203 deg. F. (—130.5 deg. C.) and boils at 173.5 deg. F. (+78.5 deg. C.).

From the foregoing it will be seen that quicksilver is unsuitable for any very low temperature and alcohol is unsuitable for any very high temperature.

Conversion of Thermometer Scales

To convert Centigrade degrees to Fahrenheit degrees, multiply by 9, divide the product by 5 and add 32, if the temperature is above 0 deg C. When the temperature is below 0 deg. deduct 32 instead of adding.

In converting Fahrenheit degrees to Centigrade degrees subtract 32, multiply by 5, and divide by 9, if the temperature is above 0 deg. F. When the temperature is below 0 deg. F. add 32 instead of subtracting.

To convert Réaumur degrees to Fahrenheit degrees multiply by 9, divide by 4 and add 32, if the temperature is above 0 deg. R. When the temperature is below 0 deg. deduct 32 instead of adding.

In converting Réaumur degrees to Centigrade degrees, multiply by 5 and divide by 4.

To convert Centigrade degrees to Réaumur degrees, multiply by 4 and divide by 5.

Centigrade, water freezes at 0 deg. and boils at 100 deg.

Fahrenheit, water freezes at 32 deg. and boils at 212 deg.

Réaumur, water freezes at 0 deg. and boils at 80 deg.

Uses of Tungsten—Tungsten is used principally as an alloy of high-speed steel—that is, steel used in making tools used in metal-turning lathes running at high speed—to which it imparts the property of holding temper at higher temperature than carbon steels will, according to the U. S. Geological Survey. The now well known ductile tungsten is used for incandescent lamps, which are fast displacing carbon lamps. This alloy is practically insoluble in all the common acids, its melting point is higher than that of any other metal, its tensile strength exceeds that of iron and nickel, it is paramagnetic, it can be drawn to smaller sizes than any other metal (0.0002 in. in diameter), and its specific gravity is 70 per cent. higher than that of lead.

Power Plant of the Government Printing Office

By Davis H. Tuck

SYNOPSIS—Wherein one plant supplies light, heat and power for the Government printing office and for the new Washington post office. The old plant was remodeled and the electrical circuits changed from a two-wire, 120-volt to a three-wire, 240-120-volt system. Test figures of the redesigned plant are given.

Due to the proximity of the new Washington, D. C., post office to the Government printing office it was deemed advisable to obtain energy for heat, light and power from the power plant of the printing office. The electrical energy required by the printing office had increased until the distributing lines were likely to become overtaxed with a subsequent increase of load. The generating equipment had been added to from time to time until there were four units in the plant. The power-receiving circuits of the new post office were designed for 240, and the lighting system for 120 volts. The power-receiving circuits of the printing office were for 120 volts.

After an analysis of these conditions it was decided to change the two-wire, 120-volt system, to a three-wire, 240-120-volt system to meet the requirements of the new post office and at the same time increase the capacity of the distributing circuits of the printing office. It was also decided to replace one of the small reciprocating generating units by a turbo-generator of sufficient capacity to carry the load of both the printing office and the new post office. By such a change a gain in efficiency could be realized by the substitution of a more efficient prime mover and by the utilization of one unit of relatively large capacity in place of several small units.

The boilers in the plant were overtaxed during the winter months by the requirements of the printing office and were not adequate for the increased load imposed by the new post office. Therefore, it was necessary to add to the boiler equipment and, as the stack was not large enough to produce the additional draft required by the additional boilers, it was necessary to build a suitable stack.

Fig. 1 is a plan and elevation of the plant before the changes were made. The boiler equipment consisted of eight 300-hp. hand-fired Scotch-marine boilers with auxiliary apparatus including two feed-water heaters. The generating equipment consisted of two cross-compound Allis engines directly connected to two 300-kw. Crocker-Wheeler direct-current generators, one similar unit of 300-kw. capacity, and another of 125-kw. capacity. Two air compressors of 1500 cu.ft. of free air per minute capacity supply air at 50 lb. pressure to various industrial processes in the printing office. One pump of 2,000,000 gal. per 24 hr. capacity maintains a high-pressure system for industrial processes and for fire protection in both buildings.

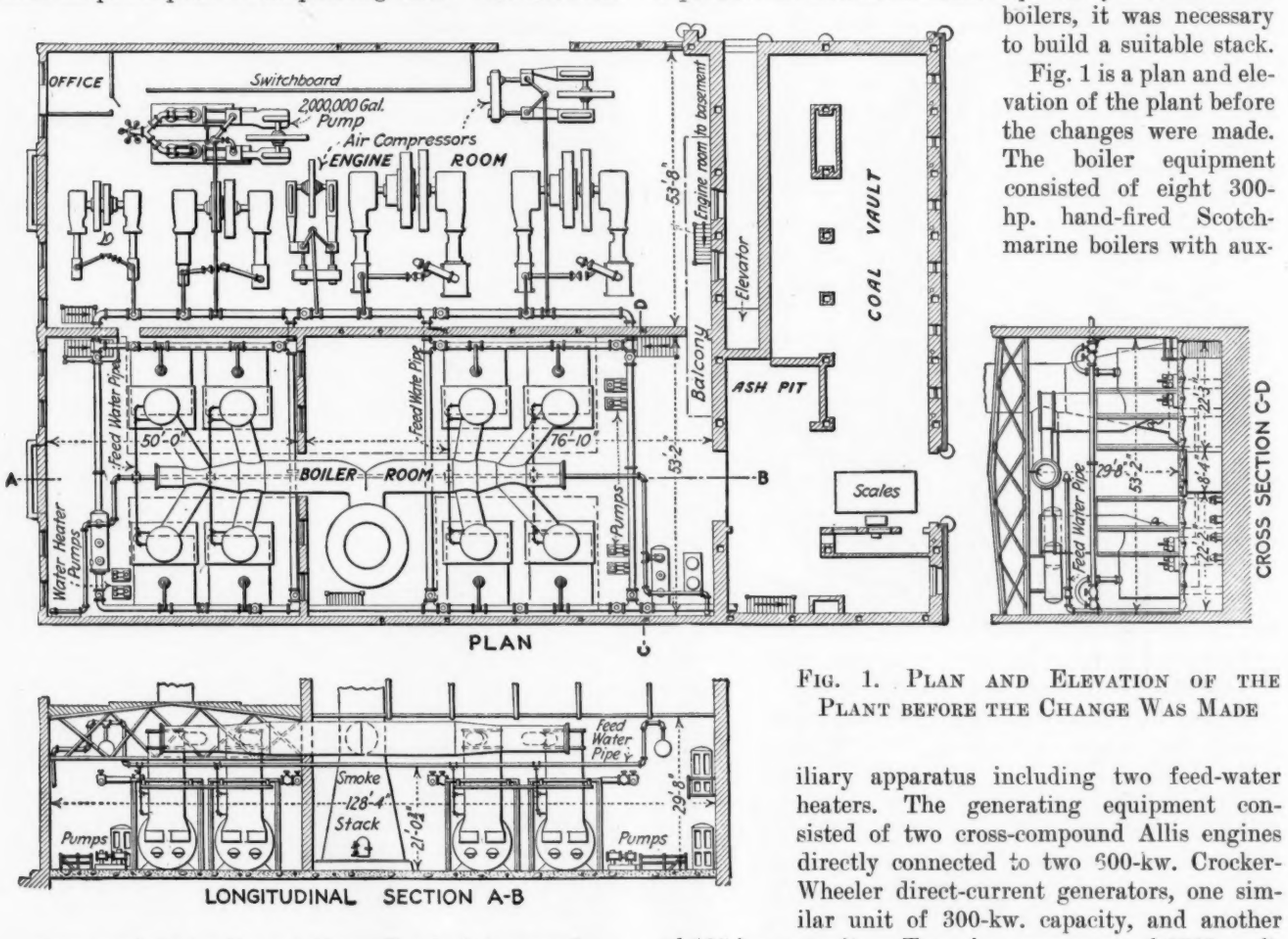


Fig. 1. Plan and Elevation of the Plant before the Change Was Made

The original plans of the changes to be made include the installing of four 500-hp. water-tube boilers with superheaters, stokers, feed pumps and piping; an alternative plan called for putting in two boilers with auxiliaries, similar to those already in place, should the appropriation not permit of water-tube boilers.

The new feed-water heater was to have a capacity for

heating the water for not less than 1600 hp. of boilers to a temperature within 2 deg. of that of the exhaust steam. All piping in that part of the boiler house which was to contain the new boilers, except the main steam header, was to be removed, and all steam, exhaust, water and waste piping necessary for the new equipment put in. Changes in the heating feed pipes in the printing office and for the post office were also to be made, and coal- and ash-handling machinery was to be put in for both the new and the old boilers. The erection of a 200-ft. chimney to be 10 ft. 6 in. inside diameter at the top to serve the new boiler was also contemplated.

The new turbine and three-wire generator were to be of 1000-kw. capacity. In the proposal for this unit it was stated that in case the guarantees of the builders

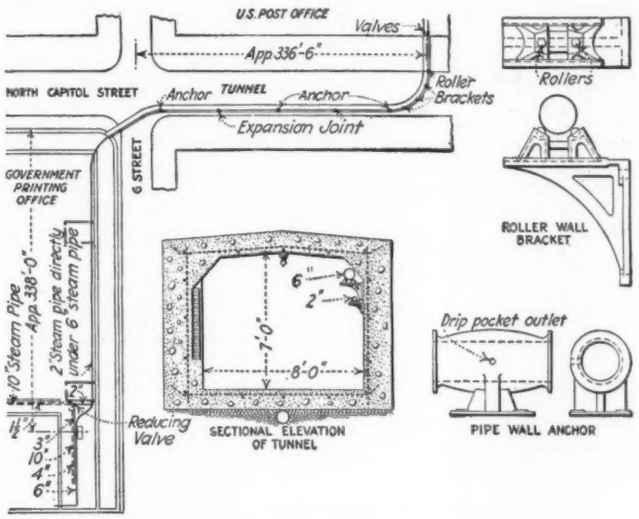


FIG. 2. DETAILS OF TUNNEL CONSTRUCTION AND WALL BRACKETS

differed, they would be evaluated for the purpose of comparison as follows: The cost to generate steam to be taken at 16c. per 1000 lb., the unit being assumed to operate 16 hr. per day, 365 days in the year, and the algebraic sum of the savings at one-half, three-quarter, full and one and one-half load, with load factors of 20, 50, 15 and 5 respectively, would represent the gross savings per year effected by the units with the lower steam consumption over the unit with higher.

The generator was to have a capacity for two hours of 150 per cent. of its normal load of 1000 kw. The maximum temperature rise of the generator, after being run at full normal load continuously for 24 hr., was not to exceed by more than 45 deg. C. the temperature of the surrounding air corrected to a standard room temperature of 25 deg. C., in accordance with the standards adopted by the American Institute of Electrical Engineers.

Changing of the 300-kw., 120-volt generator to a three-wire 120-240-volt generator and all necessary connections and wiring to the switchboard were also included in the original plans, also the changing of the switchboard and instruments from the two-wire to a three-wire system. The two 600-kw. generators were to be connected in series to form a three-wire system. There would then be installed one unit of 300-kw., one of 1000-kw. and one of 1200-kw. capacity. The switchboard was to consist of 16 panels and two sets of busbars, one for lighting and one for power, with switches so arranged that either set of busbars could be used for either lighting or power.

A tunnel from the printing office to the post office for the steam piping for heating and for the electric wiring was required, the construction of which was to conform with the plan and elevation in Fig. 2. A wall bracket, anchor and roll supports such as used are also shown. The tunnel is of course larger than necessary for this particular purpose, but was made large enough to accommodate a future mail-conveying equipment.

As the appropriation made by Congress for the additions to the power plant was not sufficient to carry out all of the improvements planned, it was decided to distribute the appropriation and purchase two 500-hp. water-tube boilers, without superheaters, one feed-water heater, all necessary piping, ash-handling machinery, chimney, turbine and generator to carry out the changes on the 300-kw. generator and switchboard and to construct the tunnel.

It was also decided to change the two 600-kw. 120-volt generators to 240-volt generators and install balancer sets for the new three-wire system instead of cross-connecting them as originally intended. The new plant therefore consists of one 300-kw. generator, two 600-kw. generators and one 1000-kw. generator all arranged for the three-wire system.

Referring to Fig. 1, the two 300-hp. Scotch marine boilers at the right of the new chimney were replaced by two 500-hp. Babcock & Wilcox, cross-drum, water-tube boilers. The old stack, which was of steel construction lined with firebrick, 6 ft. 4 in. inside diameter and 150 ft. high, was removed and the new 200-ft. brick stack was constructed as indicated. The 125-kw. unit next to the office was replaced by the 1000-kw. turbo-generator, which upon acceptance tests conformed to the guarantees of the makers. The results of the tests of the boilers and turbo-generators are given in detail in the accompanying reports.

On account of the amount of steam used for other purposes, including steam heat, live steam for industrial uses, for pumping water and for use in air compressors, a test was made on the steam-generating engines and it was found that they used about 20.5 lb. of water per kilowatt-hour. Then the total coal consumed multiplied by 20.5 and divided by the total water evaporated gives the coal consumed per kilowatt-hour. From this point the following formula is used to determine the cost of energy per kilowatt-hour.

$$\textit{Cost per kw.-hr.} = \frac{\dfrac{w \times \textit{kw.-hr.} \times c}{W} \times (Be\ Ew)\left(Ee\ De\ Ew\ \frac{o}{2}\right)}{\textit{kw.-hr.}}$$

where

W = Total pounds of water evaporated;
w = Water evaporated per pound of coal;
Be = Boiler-room expense;
De = Dynamo expense;
c = Coal per kilowatt-hour;
Ew = Engineer's wages;
Ee = Engine-room expense (engines and generators only);
o = Office expense.

The load factor, defined as the ratio of the average load

Test No. 1—Report of Steaming Test of Fuel

Results of boiler trial made by the U. S. Bureau of Mines at the Government printing office, Washington, D. C., to determine the ability to make the guarantee at 150 per cent. rating.

Principal conditions governing trial: Draft kept about constant; coal wet in hopper.

Dimensions, Proportions, Etc.

Boiler, Babcock & Wilcox Cross Drum	
Grate surface, sq.ft.	102
Water-heating surface, sq.ft.	5200
Date of trial	Sept. 22-23, 1914
Duration of trial, hr. (9:00 p.m. to 3:00 p.m.)	18.00
Method of starting and stopping test	Alternate
Kind of coal	New River

Average Pressures, Temperatures Fahrenheit, Etc.

Steam pressure by gage, lb. per sq.in.	129.3
Force of draft between damper and boiler, in. of water	0.72
Force of draft in furnace, in. of water	0.59
Temperature of air entering ashpit, deg.	94
Temperature of feed water entering boiler, deg.	72
Temperature of escaping gases from boiler, deg.	540

Quality of Steam

Per cent. of moisture in steam	0.0
Quality factor of steam (dry steam = unity)	1.000

Total Quantities

Weight of coal as fired, lb.	47,595
Per cent. of moisture in coal	3.09
Total weight of dry coal consumed, lb.	46,032
Total dry ash and refuse, lb.	4,415
Total combustible consumed, lb.	41,617
Total combustible consumed, determined from analysis of coal and refuse, lb.	41,440
Ratio of dry ash and refuse to dry coal, per cent.	9.6
Total weight of water fed to boiler, lb.	426,438
Equivalent water fed to boiler from and at 212 deg., lb.	506,608
Total water evaporated, corrected for quality of steam, lb.	426,438
Factor of evaporation based on temperature of water entering boiler	1.188
Total equivalent evaporation from and at 212 deg. F., lb.	506,608

Hourly Quantities and Rates

Dry coal charged per hr., lb.	2,557
Coal as fired, charged per hr., lb.	2,639
Combustible consumed per hr., lb.	2,312
Combustible consumed per hr., determined from an analysis of coal and refuse, lb.	2,302
Dry coal charged per sq.ft. of grate surface per hr., lb.	25.07
Combustible consumed per sq.ft. of water heating surface per hr., lb.	0.445
Water evaporated per hr., corrected for quality of steam, lb.	23,691
Equivalent evaporation per hr., from and at 212 deg. F., lb.	28,145
Equivalent evaporation per hr. from and at 212 deg. F. per sq.ft. of water heating surface, lb.	5.412

Approximate Analysis of Coal, Test Sample

	Per Cent.	As Fired, Per Cent.	Laboratory Moisture and Ash Free Per Cent.
Moisture	3.1	3.09	
Volatile matter	20.7	20.56	22.45
Fixed carbon	70.9	71.06	77.55
Ash	5.3	5.29	
Total	100.00	100.00	100.0
Sulphur (separately determined)		1.10	1.20
Moisture as fired, as per cent. of moisture and ash free coal, test sample		3.38	

Ultimate Analysis of Coal, Car Sample

	Moisture Free Per Cent.	Moisture and Ash Free Per Cent.
Hydrogen	4.5	4.77
Carbon	83.8	88.65
Nitrogen	1.6	1.72
Oxygen	3.5	3.66
Sulphur	1.1	1.20
Ash	5.5	.....
Total	100.00	100.00

Analysis of Refuse, Moisture Free

	Per Cent.
Combustible	47.0
Earthy matter	53.0
Total	100.00

Calorific Value

Calorific value by oxygen calorimeter, per lb. of dry coal, B.t.u.	14,727*	14,722
Calorific value by oxygen calorimeter, per lb. of combustible, B.t.u.	15,584*	15,574
Calorific value by oxygen calorimeter per lb. of coal as fired, B.t.u.	14,270*	14,267

*Used in computation; other determinations made as check.

Capacity

Evaporation per hr. from and at 212 deg. F., lb.	28,145
Hp. developed (34.5 lb. of water evaporated per hr. into dry steam from and at 212 deg. F. equals one hp.) B.hp.	815.8
Rated capacity per hr., from and at 212 deg. F., lb.	17,940
Percentage of builders rated hp. developed, per cent.	156.9

Economy Results

Water fed per lb. of coal as fired, lb.	8.98
Water evaporated per lb. of dry coal, lb.	9.26
Equivalent evaporation from and at 212 deg. F. per lb. of coal as fired, lb.	10.66
Equivalent evaporation from and at 212 deg. F. per lb. of dry coal, lb.	11.1
Equivalent evaporation from and at 212 deg. F. per lb. of combustible, lb.	12.17
Equivalent evaporation from and at 212 deg. F. per lb. of coal as determined from analysis of coal and refuse	12.23

Efficiency

Efficiency of boiler including grate, heat absorbed by boiler per lb. of dry coal, divided by heat of one lb. of dry coal, per cent.	72.5
Efficiency of boiler, heat absorbed by boiler per lb. of combustible, divided by heat value of one lb. of combustible per cent.	75.8
Efficiency of boiler, heat absorbed by boiler per lb. of combustible, determined from analysis of coal and refuse divided by heat value of one lb. of combustible, per cent.	76.2

Smoke Data

Percentage of smoke as observed, Ringelmann chart method per cent. black	0.0

Methods of Firing

Average thickness of fire, in.	7
Air per lb. of dry coal, lb.	16.6
Air per lb. of combustible, lb.	17.6

Analysis of Dry Gases by Volume

Carbon dioxide (CO_2), per cent	12.2
Oxygen (O_2) per cent	7.1
Carbon monoxide (CO), per cent	0.1
Nitrogen (N_2), Argon (A_2), and inert gases, by difference, per cent.	80.6
Total	100.00

Heat Value or the Distribution of the Heating Value of the Combustible

	Combustible Burned B.t.u.	Per Cent.
Heat absorbed by boiler	11,868	76.1
Loss due to evaporation in coal	42	0.3
Loss due to heat carried away by steam formed by burning hydrogen	535	3.4
Loss due to heat carried away in dry flue gases	1,944	12.5
Loss due to carbon monoxide	73	0.5
Loss due to combustible in ash and refuse	731	4.7
Loss due to heating moisture in air	.....	....
Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for	391	2.5
Total calorific value of one lb. of combustible	15,584	100.00

Test No. 2—Results of Boiler Trial at 50 per Cent. of Rating

Made by U. S. Bureau of Mines at the Government printing office, Washington, D. C., to determine the ability to make guarantee at 50 per cent. of rating.

Principal conditions governing trial: Coal wet in hopper throughout test; load steady.

Dimensions, Proportions, Etc.

Boiler, Babcock & Wilcox Cross Drum	
Grate surface, sq.ft. chain grate	102
Water heating surface, sq.ft.	5200
Date of trial	Sept. 21-22, 1914
Duration of trial, hr. (9:02 a.m. to 3:02 a.m.)	18
Method of starting and stopping the test	Alternate
Kind of coal	New River
Size of coal, run of mine	Apparently

Average Pressures, Temperature Fahrenheit, Etc.

Steam pressure by gage, lb. per sq.in.	129.4
Force of draft between damper and boiler, in. of water	0.11
Temperature of air entering ashpit, deg.	98
Temperature of feed water entering boiler, deg.	71
Temperature of escaping gases from boiler, deg.	360

Quality of Steam

Per cent. of moisture in steam	0.2
Quality factor of steam (dry steam = unity)	0.998

Total Quantities

Weight of coal as fired, lb.	22,890
Per cent. of moisture in coal	2.71
Total weight of dry coal consumed, lb.	22,272
Total dry ash and refuse, lb.	2,545
Total combustible consumed, lb.	19,727
Total combustible consumed determined from analysis of coal and refuse, lb.	19,771
Ratio of dry ash and refuse to dry coal, per cent.	11.4
Total weight of water fed to boiler, lb.	215,172
Equivalent water fed to boiler from and at 212 deg. F., lb.	255,840
Total water evaporated corrected for quality of steam, lb.	214,742
Factor of evaporation based on temperature of water entering boiler	1.189
Total equivalent evaporation from and at 212 deg. F., lb.	255,328

Hourly Quantities and Rates

Dry coal charged per hr., lb.	1237
Coal as fired, charged per hr., lb.	1272
Combustible consumed per hr., lb.	1096
Combustible consumed per hr., determined from an analysis of coal and refuse, lb.	1096
Dry coal charged per sq.ft. grate surface per hour, lb.	12.13
Combustible consumed per sq.ft. of heating surface per hr., lb.	0.211
Water evaporated per hour, corrected for quality of steam, lb.	11,930

Test No. 2—*Continued*

Approximate Analysis of Coal. Test Sample

	Per Cent.	As Fired, Per Cent.	Moisture and Ash Free Per Cent.
Moisture	2.7*	2.71	
Volatile matter	21.5*	21.35	23.29
Fixed carbon	70.2*	70.30	76.71
Ash	5.6*	5.64	
Total	100.00	100.00	100.00
Sulphur separately determined		1.13	1.23
Moisture as fired, as per cent. of moisture and ash free coal, test sample		2.94	

Ultimate Analysis of Coal. Car Sample

	Moisture Free Per Cent.	Moisture and Ash Free Per Cent.
Hydrogen	4.4	4.71
Carbon	84.6	89.80
Nitrogen	1.6	1.74
Oxygen	2.4	2.52
Sulphur	1.2	1.23
Ash	5.8	
Total	100.00	100.00

Analysis of Refuse, Moisture Free

	Per Cent.
Combustible	47.9
Earthy matter	52.1
Total	100.00

Calorific Value

Calorific value by oxygen calorimeter, per lb. of dry coal, B.t.u.	14,666*	14,706
Calorific value by oxygen calorimeter, per lb. of combustible, B.t.u.	15,569*	15,611
Calorific value by oxygen calorimeter, per lb. of coal as fired, B.t.u.	14,270*	14,308

Capacity

Evaporation per hr. from and at 212 deg. F., lb.	14,185
Hp. developed (34.5 lb. of water evaporated per hr. into dry steam from and at 212 deg. F. equals one boiler hp.)	411.2
Rated capacity per hr., from and at 212 deg. F., lb.	17,940
Builder's rated boiler hp.	520
Percentage of builders' rated hp. developed, per cent	79.1

Economy Results

Water fed per lb. of coal as fired, lb.	9.40
Water evaporated per lb. of dry coal, lb.	9.64
Equivalent evaporation from and at 212 deg. per lb. of coal as fired, lb.	11.15
Equivalent evaporation per lb. of dry coal, lb.	11.46
Equivalent evaporation per lb. of combustible	12.49
Equivalent evaporation from and at 212 deg. F. per lb. of combustible determined from an analysis of coal and refuse, lb.	12.91

Efficiency

Efficiency of boiler, including grate heat absorbed by boiler per lb. of dry coal, divided by heat value of one lb. of combustible	75.8
Efficiency of boiler, heat absorbed by boiler per lb. of combustible, divided by heat value of one lb. of combustible	80.7
Efficiency of boiler, heat absorbed by boiler per lb. of combustible, determined from analysis of coal and refuse, divided by heat value of one lb. of combustible	80.5

Smoke Data

Percentage of smoke, as observed, Ringlemann chart method, per cent. black	0.0

Methods of Firing

Average thickness of fire, in.	5.5
Appearance and action of coal on grate; burns well when wet.	
Description of flame, difficulties in handling fire, refuse, clinker, and general remarks....Short yellowish flame; refuse high in carbon.	
Air per lb. of dry coal	14.4
Air per lb. of combustible	15.3

Analysis of Dry Gases by Volume

	Per Cent.
Carbon dioxide (CO_2)	14.3
Oxygen (O_2)	4.6
Hydrogen, and hydrocarbons	0.1
Nitrogen (N_2), Argon (A_2), and inert gases (by difference)	81.0
Total	100.00

Heat Balance or Distribution of the Heating Value of the Combustible

	Combustible Burned B.t.u.	Per Cent.
Heat absorbed by boiler	12,528	80.5
Loss due to evaporation of moisture in coal	34	0.2
Loss due to heat carried away by steam formed by burning hydrogen	490	3.1
Loss due to heat carried away in dry flue gas	996	6.4
Loss due to carbon monoxide	63	0.4
Loss due to combustible in ash and refuse	900	5.8
Loss due to heating moisture in air	.....	.....
Loss due to unconsumed hydrogen and hydrocarbons, to radiation, and unaccounted for	558	3.6
Total calorific value of one lb. of combustible	15,569	100.00

Shop and Acceptance Tests of Turbine

Shop Test

Test Number	19	20	21
Date	3-5-14	3-5-14	3-6-14
Time, from	4:30	7:30	3:05
Time, to	5:30 p.m.	8:30 p.m.	4:05 a.m.
Per cent. of normal full load	50	100	150
Throttle pressure, lb. per sq.in., gage	149.5	150.3	151.5
Inlet pressure, lb. per sq.in., gage	65.2	125.8	137.4
Vacuum in l.p. outlet by mercury column	26.64	26.3	25.5
Vacuum referred to 30-in. barometer	27.53	27.22	26.46
Barometer	29.11	29.08	29.04
Temperature at throttle inlet, deg. F.	374.5	375.7	375.5
Speed shown by continuous counter indicator, r.p.m.	3642	3609	3583
Load in kilowatts	500	1000	1500
Total net lb. of steam condensed per hr.	10,862	19,161	31,329
Lb. of steam per kw.-hr.	21.72	19.16	20.9
Superheat at throttle, deg. F.	9	9.8	9

Acceptance Test

Vacuum, full load, in. of mercury	27
Vacuum, 150 per cent. of full load, in. of mercury	26.5
Temperature of injection water, deg. F.	80
Temperature of discharge water full load, deg. F.	86
With 125 per cent. full load, deg. F.	92
Injection water used, lb. per hour	1,399,380
Steam pressure, lb. per sq.in.	130

Power Plant—Statement of Operating Expenses

September, 1914

Operation:	Total	Cost per Kw.-hr.	Remarks
Boiler-room labor	$519.67	0.164c.	
Engine-room labor	577.83	0.182	
Dynamo-room labor	445.50	0.140	
Fuel	1,530.03	0.482	
Water	.....	.....	
Engine oil	.....	.....	
Cylinder oil	51.62	0.016	
Waste	2.73	0.001	
Boiler-room supplies	79.24	0.025	Excl. of coal
Engine-room supplies	13.27	0.004	Excl. of waste and oil
Dynamo-room supplies	.....	.....	
Office force and supplies	101.01	0.032	
Ash handling	19.78	0.006	
Total	$3,340.68	1.052c.	
Maintenance and Repairs:			
Buildings and fixtures	$22.98	0.007c.	
Boilers	53.62	0.017	
Economizers	.....	.....	
Pumps	4.76	0.002	
Auxiliaries, boiler room	14.66	0.005	
Piping	28.76	0.009	
Engines	1.00	.....	
Generators	.....	.....	
Condensers	.....	.....	
Switchboard and meters	.....	.....	
Auxiliaries, engine-room	4.08	0.001	
Total	$129.86	0.041c.	
Total—power plant	$3,470.54	1.093c.	

Total output, kw.-hr., printing office	280,316.1
Total output, kw.-hr., post office	36,792.9
Total kw.-hr., including both	317,109.0
*Total coal consumed (854 tons 289 lb.)	1,913,249.0 lb.
Total lb. water evaporated	15,846,713.0 lb.
Average lb. water per lb. coal	8.28 lb.
Coal consumed for electrical purposes (350 tons 432 lb.)	784,432.00 lb.

*For all purposes.

October, 1914

Operation:	Total	Cost per Kw.-hr.	Remarks
Boiler-room labor	$601.29	0.152c.	
Engine-room labor	618.34	0.156	
Dynamo-room labor	465.85	0.118	
Fuel	1,889.93	0.477	
Water	.....	.....	
Engine oil	35.28	0.009	
Cylinder oil	.....	.....	
Waste	1.53	.....	
Boiler-room supplies	16.91	0.004	Excl. of coal
Engine-room supplies	21.22	0.005	Excl. of waste and oil
Dynamo-room supplies	1.30	.....	
Office force and supplies	80.41	0.020	
Ash handling	17.37	0.004	
Total	$3,749.43	0.945c.	
Maintenance and Repairs:			
Buildings and fixtures	$21.62	0.005c.	
Boilers	16.84	0.004	
Economizers	.....	.....	
Pumps	7.76	0.002	
Auxiliaries, boiler room	33.74	0.009	
Piping	26.12	0.006	
Engines	14.70	0.004	
Generators	.....	.....	
Condensers	.....	.....	
Switchboard and meters	.....	.....	
Auxiliaries, engine-room	1.87	.....	
Total	$122.65	0.030c.	
Total—power plant	$3,872.08	0.975c.	

Total output, kw.-hr., printing plant	332,521.2
Total output, kw.-hr., post office	63,400.5
Total output, kw.-hr, both	395,921.7
*Total coal consumed (tons 1220+2225 lb.)	2,735,025.0 lb.
Total lb. water evaporated	22,288,832.0
Average lb. water evaporated per lb. coal	8.13
Coal consumed for electrical purposes (tons 439+1249 lb.)	984,609 lb.

*For all purposes.

for the twenty-four hours to the maximum load for that time, is about 71.7 per cent.

The cost per kilowatt-hour for electrical energy is low as compared with the figures prevalent for plants of this size. It will be noted, however, that there are no overhead charges such as interest, depreciation and insurance. The Government carries no insurance, and because of the method of securing money for new apparatus by appropriation from Congress it is not necessary to make interest and depreciation charges.

The plant is now operating under the new conditions and all changes were made without any interruption to the service.

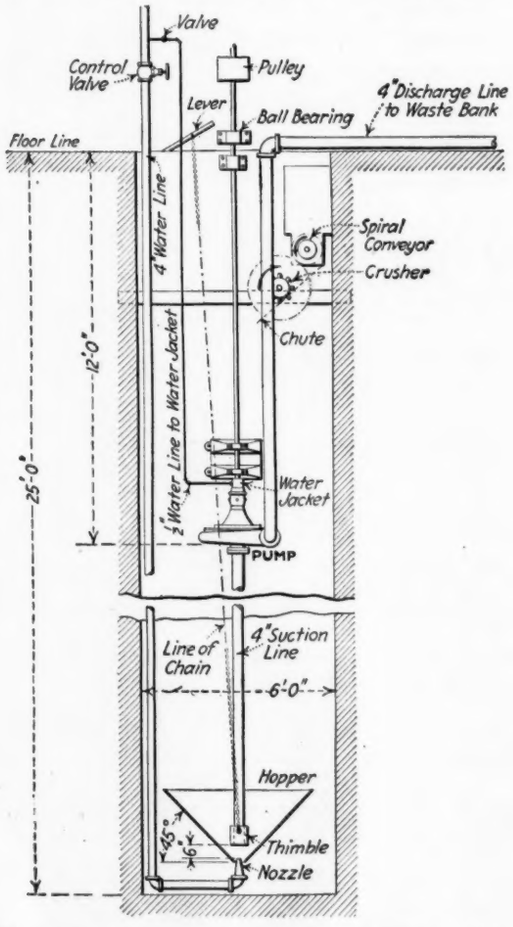
The work enumerated herein was designed by and the equipment installed under the direction of W. R. Metz, M. E., Superintendent of Buildings.

The old equipment was removed and the new equipment installed by the W. G. Cornell Co., acting as general contractors.

Dredge Pump Handles Ashes

By O. D. Havard

The Giant Portland Cement Company, Egypt, Penn., has developed a method of handling its boiler-room ashes which is believed to be new. It is an application of the centrifugal dredging pump which confines its use to



Elevation of Apparatus for Handling Ashes

plants having plenty of cheap water and those which waste the ashes within a few hundred feet of the building. The apparatus described was adopted, not because it was believed to be in all respects the best for the purpose, but because it was at hand.

The plant consists of four 250-hp. and one 400-hp. water-tube boilers, hand-fired with anthracite barley coal. The grates are stationary and the ashes are drawn through the front doors. In front of the boilers and just under the floor is a 12-in. spiral conveyor; a small opening under each boiler door is provided for the ashes to enter. During cleaning, a stream of water is turned into the conveyor at its head, which serves to quench the heat and assist the conveyor by partially floating the ashes. The ashes are discharged into a crusher which reduces the clinkers to pieces of about two inches diameter. This crusher is home-made and consists of a cast-iron cylinder 8¼ in. in diameter by 12 in. long, with 1-in. spikes driven into tight-fitting holes and projecting 2 in. These rows straddle stationary spikes 2 in. apart. The cylinder is driven by a gear from the conveyor shaft. From the crusher the ashes drop into the well where a 4-in. horizontal-type dredging pump is mounted on the side wall, the weight of the shaft and runner being carried by a ball bearing at the floor level. The suction pipe is bent to come in the center of the well and terminates about a foot above the bottom. A 4-in. water pipe is led down and turned up, with a 2½-in. nozzle directly under the suction and 6 in. away. The pump gland is water-sealed by a ½-in. pipe tapped in above the 4-in. control valve. The water pressure at the valve is about 25 lb. The discharge, consisting of a 4-in. pipe, is led up and out to the waste bank. A thimble of 5-in. pipe is put over the suction and connected by a chain to the lever at the floor.

The process of operation is as follows: Drop the thimble before turning the ashes into the well to keep from obstructing the water pipe; run in all the ashes the well will hold. When ready to pump out, open the 4-in. valve four turns and open the gland water valve. Allow water to rise over the pump runner before starting. When the pump has run a short time on water only to insure the discharge pipe being clean, raise the thimble and allow the ashes to mix with the water. As high as fifteen cleanings have been put into the well before pumping out and have then been ejected in 30 min. The speed of the pump is 658 r.p.m. The variation of speed with head, as given by the manufacturer, is:

Head in Feet	Speed, R.p.m.	Head in Feet	Speed, R.p.m.
5	230	40	727
10	364	50	812
15	447	60	890
20	515	70	960
25	574	80	1000
30	630	90	1085
35	680	100	1145

Four horsepower is required for each ten-foot elevation.

The Colorado River Basin—A recent publication by the United States Geological Survey contains much information of value to all water users. All people interested in the water flowing in the streams of the great Colorado River basin should become familiar with the reports on the subject published by the United States Geological Survey. Such reports, covering the entire country, appear each year in twelve parts, as water-supply papers. Part 9 of this series is devoted exclusively to the Colorado River basin. This paper gives the results of measurements of flow made at about 140 regular river observation stations in the states of Colorado, Wyoming, Utah, New Mexico, and Arizona, and at about 60 miscellaneous points in those states. This information is necessary for the proper and economical installation and operation of water-power plants, irrigation projects, systems of municipal water-supply, works for the prevention of damage caused by devastating floods—in fact, all works that involve the use or control of water.

Editorials

Choosing a Profession

A correspondent recently asked us if we would advise him to continue studying electricity when he prefers steam engineering. We replied to this, as we would to any similiar question, that on general principles it is wise to study the subject which most appeals to one, and that anyone is most apt to succeed at the calling he likes best. It is better to be a successful steam engineer than a failure at anything else, no matter how much more attractive the other position might seem to be.

The young man's doubt arose from his feeling that steam was getting out of date. This, of course, is ridiculous, for the present at least. There is no denying that water power is gaining in use, and fortunately so, for the coal supply is certainly diminishing, but there will be plenty of fields for good steam operating engineers until long after this generation has finished thinking about it. There is a lot of truth in the verse foreword in this issue.

Cultivating an Engineering Hobby

The temptation to scatter one's energies over too great an area is particularly strong in engineering. The various branches of the profession are so inclusive, and the limitations of the individual are so marked, that the desire to make use of every possible opportunity to broaden one's knowledge of applied science often carries a man off his feet, so to speak, and results in a good deal of intellectual lost motion. Experienced men know how to guard against the dissipation of their resources, and one of the best methods is the cultivation of a hobby within the field of one's work.

By this is meant settling one's thoughts largely upon one special line of practice for a stated period, such as the rest of the winter and the early spring, and concentrating all one's extra efforts in the endeavor to acquire a real mastery of the selected subject. Thus, one man will decide to make a study of mechanical stokers, getting every catalog and reading every printed thing he can lay hands upon in this connection during the next two months or so, talking with men who operate, buy, sell and repair stokers, besieging the local public library for books containing matter on this theme, and absorbing data and information with might and main at every opportunity. Another man may prefer to take up the study of coal, following so far as he may the latest advances in its laboratory testing by the government, getting the new points of view regarding the volatile products of combustion, and perhaps reading about the methods of mining and preparing fuel for market. The next man may prefer to start a system of interchanging and comparing operating data among engineers of his acquaintance; another may want to master standard wiring methods or study the limitations of the gas engine and the producer.

All such work has real value. It should not blind a man to what is going on in the field as a whole, but giving direction to his special interests, it enables progress in mental acquisition to be cumulative and thus tends to lead one further into the mastery of a special subject than is possible by mere desultory reading and observation.

One engineer began a collection of station-operating costs in this way, and became so interested in the subject that he filled many pages of a notebook with comparative figures of the same and of different plants for three or four years. Much of the data were obtained from returns on file with the Public Service Commission of his state, and ultimately he was able to sell some of the material to outside interests who heard that he was assembling these costs, figured upon both unit and total bases. The material sold was all public property, being reported to the state annually, although few people knew of its existence, and in its study the engineer observed many interesting tendencies of practice, noting particularly the effect of larger generating units upon the cost of labor per kilowatt-hour, the influence of the day-load upon station efficiency, and other valuable data.

The best thing about thus cultivating what might be called a transient specialty is the enduring grasp of the subject which, if once acquired, never entirely leaves one high and dry in dealing with it later, but broadens the interest of the busy engineer in many inter-related branches of his profession.

Safe Piping

We have laws or ordinances regulating the use of boilers, the installation of electric wiring, plumbing and for safe building construction, yet for some unknown reason nothing in this direction has been accomplished with regard to the safety of steam piping. There is not even a rule making imperative the use of nonreturn valves at the boiler, and at both boiler and header when more than one boiler is used on pressure, possibly because these valves cost more than the ordinary globe or gate valves. The deciding consideration of all work seems to be the price; the safety of plant and humanity are usually secondary considerations.

Engineers seem to be averse to specifying exactly whose apparatus they require; such and such a make "or equal" is the usual way of putting it, possibly to avoid misinterpretation as to motive. However, more than one manufacturer's material is good, and why not mention more than one name, being particular in each case to specify each maker's classification? The pecuniary motive will at least be absent, the specification will be clearer to all interested, and such a practice will go far toward discouraging the sale of competing material now on the market, which is invariably sold as the "equal." It is also well to remember that ability of this "equal" material to fulfill its name is often left to the judgment of others, who may not be as conscientious as the engineers. The usual clause relating to a guarantee for defective material and work-

manship is akin to locking the stable after the horse is gone. What good can the guarantee and actual replacing of defective material do to those physically injured?

It should be the aim of engineers to secure laws looking to the safety of piping work—in fact, the safety of all engineering work. Particularly where pecuniary interest can work against the safety of human life, the use of safety devices must be imperative. Rules as to layout and material, based upon past experience, must be enforced. This will also give the engineer a freer hand in designing for the penurious owner, whose sole aim is to get out as cheaply as possible.

Making the Most of Efficiency Instruments

In the report of the Committee on Prime Movers, presented at the Philadelphia convention of the National Electric Light Association, the point was made that a feeling exists among power-plant owners that the use of so-called "efficiency instruments" has been in a measure instructive, but that on the whole the results have been disappointing. The apparent reason set forth is that it was supposed that an operator with such an instrument before him would interpret the record and apply the obvious remedy for any poor results, whereas in reality, the plant does not realize from automatic station records the benefits which these might be made to yield. This is an important matter for consideration, in fairness to the busy operating engineer and in justice to his employer.

It is possible to load down a plant with automatic instruments whose records and indications give very little help to those in charge of the installation, but many plants suffer from the lack of instruments in important locations where moment-to-moment records would be of immediate help in operation. Without desiring to condemn any particular apparatus, unless equipment of this sort makes extremely direct measurements of a simple kind, its immediate usefulness to the operator is problematical except where such records have been interpreted by exhaustive comparisons with other periods, and this is a species of research work for which many engineers have no time. The interpretation of highly analytical records, in connection with some of the larger power stations, is therefore assigned to specially designated efficiency engineers having a technical knowledge of thermodynamics and chemistry, who are not burdened with routine operating duties and who report direct to the chief engineer all conclusions and recommendations, based upon a continuous analysis and study of the significant records of plant performance and personal knowledge of station apparatus and operating conditions. The distinction between operation and the analysis of plant data is a real one, and in companies where the output is large enough to warrant the expense, such a division of labor may be very useful.

In most plants, however, the control of production economy must rest in the hands of those who run the station from shift to shift, supplemented by occasional or, preferably, regular studies of performance by the engineering staff. Day after day, as the load varies, it is important to keep various pressures and temperatures, volumes and weights close to predetermined figures. For such work reliance upon steam gages, steam meters, coal scales, watt-hour meters, draft gages, and, almost above all else, upon thermometers located at strategic points, must take the place of so called continuous graphic test records whose significance cannot be taken without considering their relation to other and complex phenomena. To take the case of the carbon-dioxide recorder, for example, it should be clear that unless such data as this apparatus gives apply to the plant as a whole and not to a single boiler uptake, little immediate use can be made of the observations yielded.

In a nutshell, it is better to determine by tests what temperatures, pressures and volumes spell maximum plant efficiency for a given load and operating conditions and to try to approximate those readings, than to attempt to rapidly interpret highly complex indications drawn from portions of the station only, without having time to weigh and balance a wide range of such data. That is, efforts should be concentrated upon maintaining instrument readings known to be favorable to economy of operation, leaving the comparison of complex indications for the time when analyses can be studied at will.

There is room for establishing in many plants certain limits of operating efficiency expressed in maximum and minimum instrument readings, to stay between which should be the main object of the engineer's routine work. Prompt adjustment of fuel supply, water supply and air is more necessary in meeting the momentary conditions of service than drawing academic parallels between the percentage of ash in the pit of boiler No. 6 today and the same date of last year. For efficient handling of a plant one must have, first, a staff responsive to changes in its service conditions and competent to recognize the limits of efficient manipulation of individual apparatus, and second, the ability within the reach of the plant to draw from station history conclusions of value in meeting the demands of daily routine and emergency service.

Popularity among his fellows is a big asset to an engineer, but unless he has a commensurate amount of professional competency behind it, he's some day going to be a disappointment to himself and his friends.

The report of the commission which began about three years ago to investigate the use of electricity in the Netherlands states that the managements of a number of industrial concerns are of the opinion that it is most advantageous to furnish their own power. Many an American manufacturer found that out long ago.

On January 16, 1909, President Roosevelt sent to Congress a special message which seized the occasion of his veto of an apparently innocent bill granting water-power rights in Missouri to proclaim the discovery of a brand new trust—the Water-Power Trust—and to denounce it as a menace to the people which in a short time would be worse than even the Standard Oil Company.

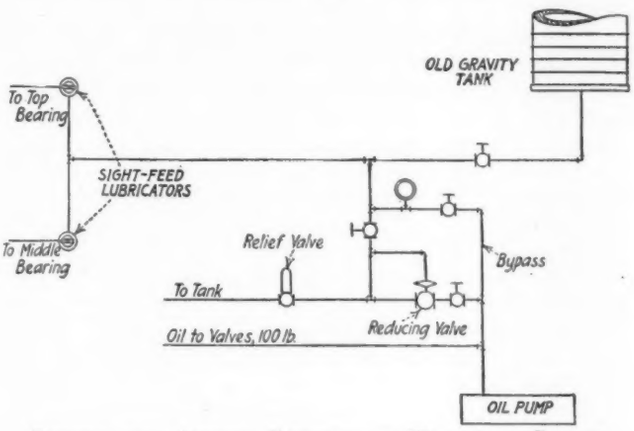
"The movement is still in its infancy," declared the President, "and unless it is controlled, the history of the oil industry will be repeated in the hydro-electric-power industry with results far more oppressive and disastrous for the people."

Subsequent developments have shown that it was no mare's-nest that the President unearthed. The "new trust" has proven itself powerful enough to hold up any legislation insuring the perpetuation of the people's rights in the water power of the country.

Correspondence

Changes Turbine Oiling System

The top and middle bearings of our 2000-kw. Curtis vertical turbine formerly received lubricating oil fed by gravity from an overhead tank. We were dissatisfied with this method of feeding and decided to take oil from the valve-oil line and run it through a reducing valve to the



PIPING FOR OILING SYSTEM OF VERTICAL CURTIS TURBINE

bearings. The hydraulically operated valves receive oil at 100-lb. pressure; the bearing-oil pressure is now maintained at 18 lb.

The changes made in the piping are shown in the sketch. The amount of lubricant fed to the bearing is controlled by manipulating sight-feed valves. We are well pleased with the change.

WILLIAM JOHNSON.

Newton Square, Penn.

Gas-Engine Cooling Water

The article on "Gas-Engine Cooling Water," by G. A. Field, in the Mar. 30 issue, contains some statements which do not seem to be in accord with good practice.

Discussing thermo-siphon cooling systems in small engines, he states that the bottom of the water tank should not be below the level of the water outlet of the cylinder jacket. He evidently means the jacket inlet opening, but even in this case the statement is not correct. It is usual in small engines to place the water tank so that the bottom is on a level with the engine base, with the tank outlet opening some three or four inches from the bottom, this being connected to the engine by the necessary pipes and elbows. It is safe to say that 90 per cent. of tank-cooled engines are arranged in this way and are giving perfect satisfaction.

In constructing an overhead tank special emphasis should be placed on the fact that, if the tank is placed at too great a height, there is danger of cracking the cylinder jacket. Many engines do not have a thick jacket wall and, stressed as it is by expansion, the jacket does not require many pounds of water pressure to fracture it. I recall one installation where the cooling tank was placed on the roof of a three-story building, and the jacket fractured the first day the engine ran. When a new cylinder was received it also developed a crack after a few hours' run. It was decided that the hydrostatic head due to the height of the tank caused the trouble. This was partially demonstrated when the tank was placed at the rear of the engine room, and no further trouble was experienced.

L. H. MORRISON.

Fremont, Neb.

Changing Speed of Three-Phase Induction Motor

A two-speed, three-phase, 50- to 125-hp. induction motor, used to drive a rotary pump for pumping salt water into the fire mains for fire protection and for flushing purposes, was found to be too slow on the low speed to be of any use for flushing, as it gave only 30 lb. pressure on the mains and would not raise the water to the highest point in the flushing system. Therefore, the pump had to be run at the high speed all the time, using nearly 100 kw. and leaving the low-speed winding useless.

For the two different speeds, the motor has two windings on the stator, which are entirely independent of each other. The high-speed winding has 6 poles, with the coils connected on the inner end of the motor, and the low-speed winding had 10 poles, with the coils connected on the outer end. There are 90 slots in the stator, making

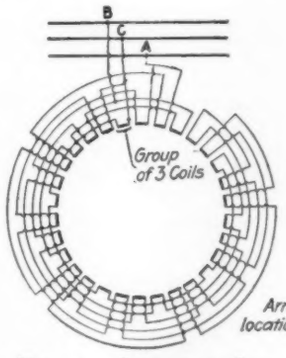


FIG. 1. ORIGINAL CONNECTIONS

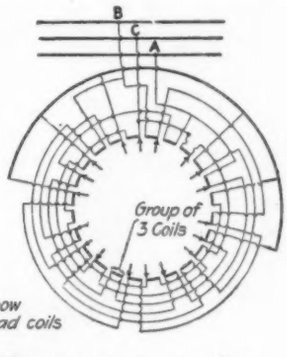


FIG. 2. CHANGED CONNECTIONS

it suitable for both a 6-pole and a 10-pole, three-phase winding, but not for an 8-pole winding, if all the coils were to be used.

After careful consideration it was decided to change the low-speed winding from 10 poles to 8, leaving 18 of the coils idle. A change was also made from delta to star connection and from series to parallel to increase the conductivity for the greater current necessary.

Fig. 1 shows the connections as they were for 10 poles, and Fig. 2 for 8 poles. The actual work of making the change was simple and cost only a few dollars, being paid for by the saving effected in less than a week's time.

The motor, when tested out at no load and at full load, was found to run just as well as when connected as a 10-pole motor with all the coils in use. It has been running almost constantly for over two years on the low-speed as an 8-pole motor, giving 45 lb. pressure on the mains, which is all that is needed, and using only 40 kw., thus making a saving of over 1400 kw.-hr. per day.

W. R. BANKHEAD.

Bremerton, Wash.

Corrosion of Iron and Steel Pipe

The conclusion of C. O. Standstrom in the issue of Mar. 23, page 416, that there is no vital difference between wrought iron and the steel used in its place will doubtless be concurred in by many who have attempted to distinguish between these two materials by ordinary tests. The reason is that the recent advances in the art of steel making have produced a steel which has nearly all the ordinary characteristics of wrought iron. It is tough, soft and stronger than wrought iron and does not harden when quenched from a red heat.

Of its many uses, the one of most importance to the engineer is in tubes and pipes. When welded pipe was first made, wrought iron alone was available, and for several years after the advent of steel its use was not even considered for welded pipe, but recently a pipe steel has been developed. Following are the comparative chemical analyses and physical tests of steel and wrought pipe as reported in the 1913 "Proceedings of the American Gas Institute:"

	Steel Pipe, per Cent.	Wrought-Iron Pipe, per Cent.
Chemical Analysis—		
Silicon	0.01	...
Sulphur	0.05	0.03
Phosphorus	0.10	0.17
Manganese	0.30	trace
Carbon	0.07	trace, irregular
Oxides (slag)	0.10	1.20 to 2.00
Physical Properties—		
Tensile strength	58,000 lb. per sq.in.	46,000 lb. per sq.in.
Elastic limit	34,000 lb. per sq.in.	28,000 lb. per sq.in.
Elongation	22 per cent. in 8 in.	12 per cent. in 8 in.
Reduction in area	55 per cent.	25 per cent.

It will be noted that wrought iron contains considerable cinder, or slag, a peculiarity of wrought iron as made by the old puddling process. This slag can frequently be observed in a cross-section of iron pipe, especially with the aid of a magnifying glass. The tensile strength of the iron was measured when the sample was pulled longitudinally, and would be considerably less if pulled transversely to the direction of rolling, while the steel is practically of the same strength in all directions. A wrought-iron pipe, therefore, will fail under a lower bursting pressure than one of steel. At first, considerable difficulty was experienced in threading steel pipe, and dies which would cut a fairly good thread on wrought pipe would make a ragged thread and work hard on steel, but correctly designed dies with more rake and relief have been made.

As to their relative durability and resistance to corrosion there is much contradictory evidence, and it is difficult to separate fact from prejudice. One of the most generally accepted theories is that corrosion is due to electrolytic action, and such conditions seem to affect both iron and steel alike. It is true that structures made from puddled wrought iron have remained in good condition after exposure to the elements for more than a century. On the other hand, under certain conditions, iron and steel pipes installed together have been destroyed by corrosion within a few months, both being about equally affected.

With its passing it seems likely that wrought iron is esteemed more on account of its past reputation than because of any distinct superiority over the modern product. It is also quite probable that much of the so-called wrought iron supplied to the trade at the present time is in reality steel, and the satisfaction it gives depends upon its quality and whether it is adapted to the purpose for which it is used.

WILLIAM A. DUNKLEY.

Atlantic City, N. J.

C. O. Sandstrom states that there are no reliable data regarding the relative ability of iron and steel pipe to resist corrosion. The following is taken from the *National Bulletin:*

Prof. T. N. Thompson in March, 1906, installed alternate pipes of the two metals in a hot-water line, and at the end of a year discovered that steel pipe had approximately 7½ per cent. longer life than wrought iron under such conditions. In a similar test carried out by a committee appointed by the American Society of Heating and Ventilating Engineers with iron and steel pipe made by various companies, Professor Thompson reported: "We believe this test demonstrates that modern steel pipe of good quality is at least as durable as modern strictly wrought iron and is very much superior to a poor quality wrought iron in this class of work." (A. S. H. and V. Engineers, 1909.)

Tests carried on by the Pittsburgh Coal Co., H. C. Frick Coal Co. and others indicate that steel is at least equal to wrought iron in resisting corrosion (*Iron Age,* July 12, 1906).

In his textbook, "The Metallurgy of Iron and Steel," Stoughton, one of those who carried out exhaustive investigations, says: "The evidence goes to show that properly made steel corrodes no more than wrought iron."

J. Newton Fried, in his recent book, "The Corrosion of Iron and Steel," states that "it would appear, therefore, that when everything is taken into consideration there is practically nothing to choose between wrought iron and steel as at present manufactured" (page 286), and finally concludes with these words: "These and many other instances might be cited as illustrating the fact that good steel corrodes at much the same rate as good wrought iron" (page 288).

A. Sang, in a thorough résumé of the question, entitled "The Corrosion of Iron and Steel," says that "properly protected steel and iron rust to about the same extent, the steel doing so more uniformly," and adds, "The best quality of charcoal iron is practically as resistant as the best quality of steel used for similar purposes" (page 49), and in regard to pipe, says: "The carefully acquired experience of the largest manufacturers of tubes in the world, which induced them recently to abandon the manufacture of wrought-iron pipe, teaches that the use of steel in place of iron, at least in the United States, for the special purpose of tubing is to be preferred; the tendency of steel to pit is somewhat less than that of iron and it welds at the joint fully as well" (page 73).

Prof. Ira H. Woolson (*Engineering News,* Dec. 8, 1910) secured 89 samples of corroded pipe from seven bath houses in New York City. Of these samples 17 proved to be wrought iron and the remainder steel. He concluded: "In my judgment, from the evidence collected there was absolutely no difference in the corrosion

of the two classes of pipe; they appear to be equally susceptible to the attack."

Dr. W. H. Walker (New England Water-Works Association, March, 1912), of the Massachusetts Institute of Technology, secured 64 samples of wrought-iron and steel pipe in adjacent service. These had been in use from 2 to 17 years. He reported that of the 64 samples 20 favor steel, 18 iron, 8 show no difference in corrosion and 17 no corrosion at all. These results again demonstrate that, taken on the average, there is no difference in the corrosion of iron and steel pipe. Conversations held with engineers in charge of plants during this investigation confirm the statement already made that a pipe is frequently called steel when corrosion is found to be excessive, while it is set down as iron if it rusts but little.

P. DeC. Ball (*Cold Storage and Ice Trade Journal*), in a paper read before the American Society of Refrigerating Engineers, made the following statements:

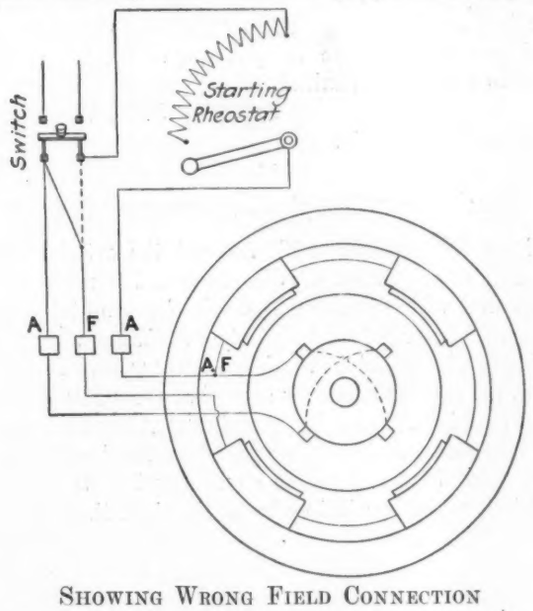
From 33 years of personal experience and observation constructing, erecting and operating ice-making and refrigerating machines, absorption and compression types, and using iron pipes for the first 14 years, and iron and steel pipes for the next 19 years, we are convinced that local conditions only govern the corrosion of pipes in refrigerating and ice-making machines, and that, chemically and mechanically, mild-steel pipe meets the requirements of the refrigerating engineers in all respects, and better than any other pipe for the reason that it is superior in point of finish, strength, strength of seam and uniformity of material.

JAMES E. NOBLE.

Toronto, Ont., Canada.

Burned-Out Starter

On account of the liability of an operator to try to start a motor with the field switch open, it is not customary to install switches in the field circuits of motors. Where standard starting boxes are used, proper connections to



SHOWING WRONG FIELD CONNECTION

the box insure that the line voltage will not be applied to the armature with the field unexcited, unless through some fault an open circuit exists. Where a starting box that does not handle the field current is used, it is safe to connect the field circuit across the service side of the line switch so that closing this switch will energize the field before the voltage can be applied to the armature, through the starting box.

Opening of the line switch then opens the field circuit, but also opens the armature circuit. Irrespective of the details of the field connection, however, if the motor fails to start when the starting handle is thrown, and flashing of the starter indicates the armature to be taking current, a piece of magnetic metal should be held to the polepieces to see if they are energized.

A manufacturer replaced a motor with a larger one which had been bought second-hand. Both motors had three leads. The shop had been rewired with larger wire for the new motor and the operator thought he had connected the second machine the same as the first. It developed, however, that he had connected the free field wire, as indicated by the dotted line, so that both ends of the field were connected to the same side of the circuit. The result was a burned starting box before he found out the trouble.

J. A. HORTON.

Schenectady, N. Y.

Efficiency Engineers

The article in the Mar. 30 issue of POWER on "Efficiency Engineers" sounds good. Why not get up a National Society of Efficiency Engineers based upon "deeds performed" as a degree of eligibility. Let applicants state the efficiency they are able to produce, as well as twelve sales or installations of merit on each account they may handle. There is a crying need for factory efficiency, particularly in this Southland, where negro labor is so prevalent. Thousands of plant managers are innocently losing a lot of money every twelve months, because they have never been "put wise" to a better way to run their plant.

J. S. HOFFECKER.

Richmond, Va.

Strenuosity and Flywheel Risks

Referring to your editorial on "Effect of High Steam Pressure on Flywheel Risks," there is another phase of the current effort to get the greatest amount of energy out of a dollar's worth of engine which you might have mentioned. The amount of energy produced *per unit of time* depends upon the piston speed as well as upon the mean effective pressure, and the raising of the piston speed from the 600 ft. per min. usual 25 years ago to the 900 or more now not uncommon makes possible an increase in energy produced per second of 50 per cent. or more from this cause alone; and this energy, in addition to that due, as your editorial pointed out, to the increased boiler pressure, is available to accelerate the flywheel.

The fact that a flywheel running with a rim speed of 90 ft. per sec. has a smaller factor of safety than one running at 60 is too obvious to mention, yet it may be well to point out again that the stress from centrifugal forces increases as the square of the velocity, is 2¼ times as great at 90 as at 60 ft. per sec., and that if the engine runs away the wheel will burst in less time starting from a rim speed of 90 than of 60 ft. per sec.

P. H. WILLIAMS.

New York City

[In the case of a runaway engine the comparison is between the piston speed *attained* and not that at which the engine is rated. At the end of a number of seconds the piston speed of a runaway engine might be greater if the piston speed to start with were 900 ft. per min. than if it were 600, but it is not at all likely that it would be 1½ times as much—EDITOR.]

Retubing Tubular and Water-Tube Boilers

With reference to J. C. Hawkins' article under this heading in the Mar. 9 issue, I wish to call attention to the statement, "The roller expander, which gives the best results and is generally used, consists . . ."

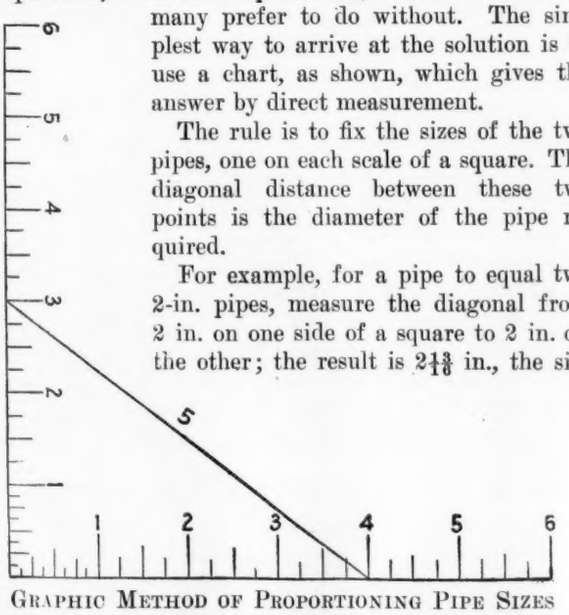
There was a time when the roller expander gave best results, because the prosser was undeveloped, but nowadays the sectional expander is more generally used. Both types have their good and their bad points. The roller expander does not bind the tube as firmly to the sheet as does the sectional tool, and there is always danger of rolling the tube too thin, although there is less danger of this with the sectional expander. The principal danger connected with the use of the sectional tool, according to the findings of the engineers of a large Eastern railroad, is that the tube sheet is liable to be cracked or unduly stressed. So far as I know, there are no other defects of this type A few years ago the roller expander was regarded as faster than the sectional, but the latter seems now to be well received.

W. F. SCHAPHORST.

New York City.

Pipe Proportions

Every engineer at some time has to solve the little problem of the size of pipe required to equal two or more other pipes, and although this is not a difficult mathematical problem, it involves square root, and that is a thing many prefer to do without. The simplest way to arrive at the solution is to use a chart, as shown, which gives the answer by direct measurement.



GRAPHIC METHOD OF PROPORTIONING PIPE SIZES

The rule is to fix the sizes of the two pipes, one on each scale of a square. The diagonal distance between these two points is the diameter of the pipe required.

For example, for a pipe to equal two 2-in. pipes, measure the diagonal from 2 in. on one side of a square to 2 in. on the other; the result is $2\frac{13}{16}$ in., the size pipe which would be sufficient; but 3-in. is the nearest commercial size.

The line from 3 to 4 marked 5 is just a reminder of the method of constructing a square. With 3 on one side and 4 on the other and the diagonal distance 5, the first two lines will be at right angles to each other, and a square is produced. The result will be the same whether the pipes are measured in any linear unit or simply pieces of wood cut or marked to length, so long as they are equal to the pipe diameters.

Mathematically, the operation is to multiply the diameter of each of the smaller pipes by itself (as $3 \times 3 = 9$ and $4 \times 4 = 16$) and add them together ($9 + 16 = 25$); then any larger pipe the diameter of which similiarly multiplied by itself equals or comes nearest the other amount (as $5 \times 5 = 25$) will have approximately the same carrying capacity as the other two.

With piping of more than 6-in. diameter it is better to use the square root of the fifth power proportion, but this brings us up against a root again and so is outside the present scheme. Still, it gives 8 in. for a combination of two 6-in. pipes instead of 8½ in. as given by the chart, so the chart is on the safe side.

R. HAMPTON.

Concepcion, Argentine.

Blowoff Piping Failures

Reference is frequently made to blowoff pipe failures and fatalities. Some of the fool things done are almost beyond belief. In a plant in which I operated the night shift the blowoff pipe was made up by screwing a nipple into the cracked outer end of the valve as far as it would go, then backing it out an indefinite number of turns on entering the other end into the next fitting. The piping was frequently disconnected and connected up again by the foregoing process. I chanced to step on the pipe in passing and it fell apart, after which I refused to blow down the boiler on account of this connection, so the owner gave it a "gingerly" little blow night and morning.

One day a new man, who was not familiar with the situation, nearly lost his life by opening the valve wide, which caused the pipe to give way. Such negligence seems to me to be criminal.

J. N. WOODRUFF.

West Liberty, Ohio.

Lubricating Commutators

I have been reading with interest the articles on the care and management of direct-current generators and motors and will mention a method of commutator lubrication that I have found entirely satisfactory. Since employing it I have had no trouble, whereas previously I had to give the commutators my attention every few hours. I take some ½-in. square flax packing that has been treated with beeswax and tallow, cut a piece the length of the commutator bars and lay it on in front of the brushes, the friction holding it in place. A piece that will just fit between the end of the brush-holder and the commutator with a little pressure is better, for the friction holds it up against the brushes and there is enough lubricant from the packing to keep the brushes well lubricated. The wiping effect on the commutator keeps it clean and in a few days a nice polish will be observed.

After running the machine for a week or so, note if there is any copper wiping over the mica; if there is, simply take a sharp file and undercut the latter a little.

C. E. CUMMINGS.

Boulder, Colo.

Inquiries of General Interest

End Play of Crankshaft—What may be the causes of end play of the shaft of a vertical engine?

F. J. I.

Endplay may be caused by the crankpin brasses being out of line and bearing alternately on opposite ends of the crankpin, or to the shaft being out of line causing a wobbling motion of the flywheel, or in a single-crank engine, to lost motion in the crankshaft bearings.

Breakage of Firebox Stay-Bolts—What is the cause of breakage of the ordinary form of firebox stay-bolts?

J. M. B.

The chief cause is unequal expansion of the two sheets which are connected, one being usually in full contact with the fire and the other being heated only to the temperature of the confined water. This difference in temperature of the sheets gives rise to considerable relative motion between the two sheets resulting in formation of cracks in the stay-bolts near the inner surface of the sheets.

Use of Boiler-Tube Ferrules—What is the purpose of using ferrules on the ends of boiler tubes?

G. B.

Ferrules are used where the effects of expansion are severe upon the tube ends, as in locomotives and boilers having firebox tube sheets. Soft-copper ferrules are also used for filling tube-sheet holes that are too large for properly receiving the expansion of the tube ends. In cases where the tube material is especially weak or thin and is therefore likely to spring back when expanded, strong ferrules of hard brass or steel are driven inside of the tubes at the ends.

Position of Crankpin at Half-Stroke—In a horizontal engine does the crankpin stand vertically over or under the shaft when the piston is in the middle of its stroke?

W. L.

It cannot, for when the crosshead is in the middle of its stroke the distance from the center of the crosshead pin to the center line of the shaft is equal to the length of the connecting-rod, and as this is less than the distance from the center of the crosshead pin to the center of the crankpin when vertically over or under the center of the shaft, the crosshead must be at some distance from half-stroke toward the shaft for the connecting-rod to place the crankpin vertically over or under the shaft.

Maximum Capacity of a Boiler—What is meant by the maximum capacity of a boiler?

H. G.

The term refers to the boiler's highest rate of evaporation, or the largest number of pounds of water the boiler can evaporate per hour under stated conditions of temperature of feed water and pressure of steam generated. For purposes of comparison the evaporation under actual conditions is usually expressed in the equivalent evaporation from feed water having a temperature of 212 deg. F. into steam at atmospheric pressure, and as steam at that pressure would have the same temperature, the standard is generally referred to as "evaporation from and at 212 deg. F."

Degrees Baumé and Specific Gravities—In stating the densities of liquids, what are the relative values of degrees Baumé and specific gravities?

J. R. C.

For liquids heavier than water the relative values are given by the formulas,

$$\text{Specific gravity} = 145 \div (145 - \text{deg. Bé.})$$

or

$$\text{Degrees Baumé} = 145 - (145 \div \text{sp.gr.})$$

and for liquids lighter than water the relative values are given by the formulas,

$$\text{Specific gravity} = 140 \div (130 + \text{deg. Bé.})$$

or

$$\text{Degrees Baumé} = (140 \div \text{sp.gr.}) - 130.$$

Case-Hardening Steel Governor Pins—How can steel governor pins be case-hardened?

M. G.

Case-hardening can be performed by heating the pin to a dull-red color, and after covering with pulverized cyanide of potassium or prussiate of potash the surfaces which are to be case-hardened, the operations of heating and coating are to be repeated. After the pin has cooled down almost to a black it is to be plunged in water and left until perfectly cold. In heating the pin the temperature should be raised gradually and so as not to burn or scale any wearing surfaces. The chemicals employed are violent poisons and care should be taken in handling them. A good way to coat the heated pin is to roll it over the pulverized chemical when spread out on a flat plate.

Resulting Temperature of Mixtures—What is the method of determining the resulting temperature of a mixture of two substances having different temperatures?

J. F.

The final temperature of a mixture of two substances of different initial temperatures is given by the formula:

$$T = \frac{(W \times S \times t_2) + (w \times s \times t_1)}{(W \times S) + (w \times s)}$$

in which

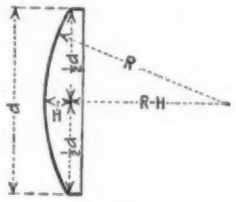
T = Final temperature of the mixture;
W = Weight of the hotter substance;
w = Weight of the cooler substance;
S = Specific heat of the hotter substance;
s = Specific heat of the cooler substance;
t_2 = Initial temperature of the hotter substance;
t_1 = Initial temperature of the cooler substance.

To Find Radius of Bumped Head—Knowing the diameter and height of bumping of a steam drum head what is the formula for determining the radius to which the head is bumped?

L. B. R.

In the figure if
R = The radius to which the head is bumped,
d = The diameter of the head, and
H = The height to which the head is bumped,
then

$$R^2 = \left(\frac{d}{2}\right)^2 + (R - H)^2$$



from which

$$2RH = \left(\frac{d}{2}\right)^2 + H^2,$$

or

$$R = \frac{d^2}{8H} + \frac{H}{2}$$

that is, the radius of bumping is equal to the square of the diameter divided by eight times the height of the bump, plus one-half of the height.

Boiler Efficiency—What was the efficiency of the boiler and grate using 14,278 lb. of coal having a calorific value of 13,000 B.t.u. per lb. for evaporation of 11,315 gal. of water from a feed temperature of 170 deg. F. into steam at 110 lb. gage pressure?

V. K. S.

Allowing 8⅓ lb. per gal., the water evaporated amounted to

$$11{,}315 \times 8\tfrac{1}{3} = 94{,}291.6 \text{ lb.}$$

and the pressure of the steam was approximately

$$110 + 15 = 125 \text{ lb. per sq.in. absolute.}$$

Referring to Marks and Davis' steam table it is seen that at 125 lb. absolute, each pound of steam contains 1190.3 B.t.u. above 32 deg. F., and as the temperature of the feed water was 170 deg. F., or 170 — 32 = 138 deg. F. above 32 deg. F., each pound of feed water must have received

$$1190.3 - 138 = 1052.3 \text{ B.t.u.}$$

so that the total heat received from the boiler was

$$94{,}291.6 \times 1052.3 \text{ B.t.u.} = 99{,}223{,}050.68 \text{ B.t.u.}$$

and as the coal contained

$$14{,}278 \times 13{,}000 = 185{,}614{,}000 \text{ B.t.u.}$$

the efficiency was

$$(99{,}223{,}050.68 \times 100) \div 185{,}614{,}000 = 53.4 \text{ per cent.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Cookson Return Steam Trap

The illustration, Fig. 1, is a semisectional view of the new Cookson return steam trap. The device is compact, simple and positive, and it has a powerful valve mechanism. It is easily accessible, is regrindable, and the disk and reversible seats are made of monel metal.

The operation of the trap is simple. Fig. 1 shows it in a filling position with the boiler pressure on the outlet check valve. When the returning condensation is to go to the boiler, the trap is located three or four feet above the water line, so that the water will drain to the boiler by gravity. If any returns are below the water line the pressure on them must be sufficient to elevate the water into the trap.

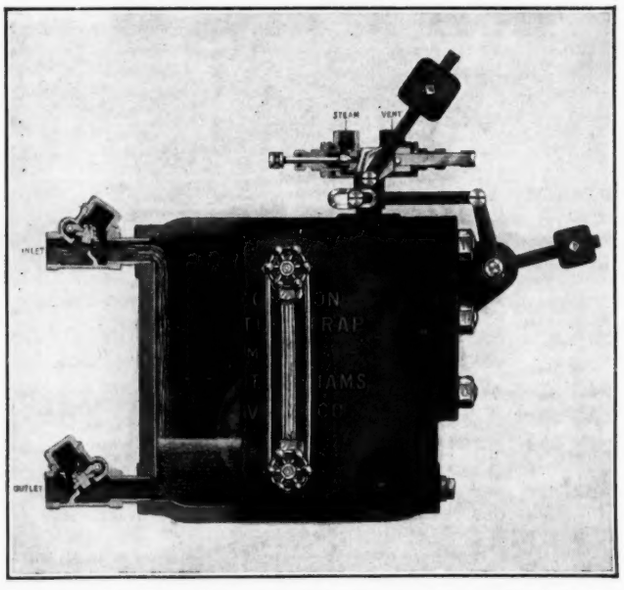


FIG. 1. SEMI-SECTIONAL VIEW OF THE TRAP

The accumulation of a given amount of water in the trap causes an upward movement of the float, Fig. 2, which communicates with the valve mechanism to the counterbalanced quadrant and connecting-rod. This action tilts the weighted valve lever, which opens the steam valve and lets the boiler pressure into the trap, closing the check valve on the inlet end. With the pressure in the boiler and in the trap equalized, the water flows to the boiler by gravity. After discharging, the floats drop and the weighted valve lever is tilted to its former position, automatically venting the trap of boiler pressure, and allowing condensation to flow into it until a sufficient amount has again accumulated to cause it to repeat the operation of discharging into the boiler.

To provide against any loss of steam a water seal of several inches remains in the trap after each discharge. Fig. 2 shows a detailed drawing of the trap and the valve-operating mechanism. The only thing in the body of the trap is the high-pressure float that actuates the valve mechanism. The design of the valve and seat makes it possible to regrind them while the trap is in operation. As the valve mechanism is on the outside of the trap it is easily accessible, and its movement indicates whether the trap is in operation or not. This trap is manufactured by the D. T. Williams Valve Co., Cincinnati, Ohio.

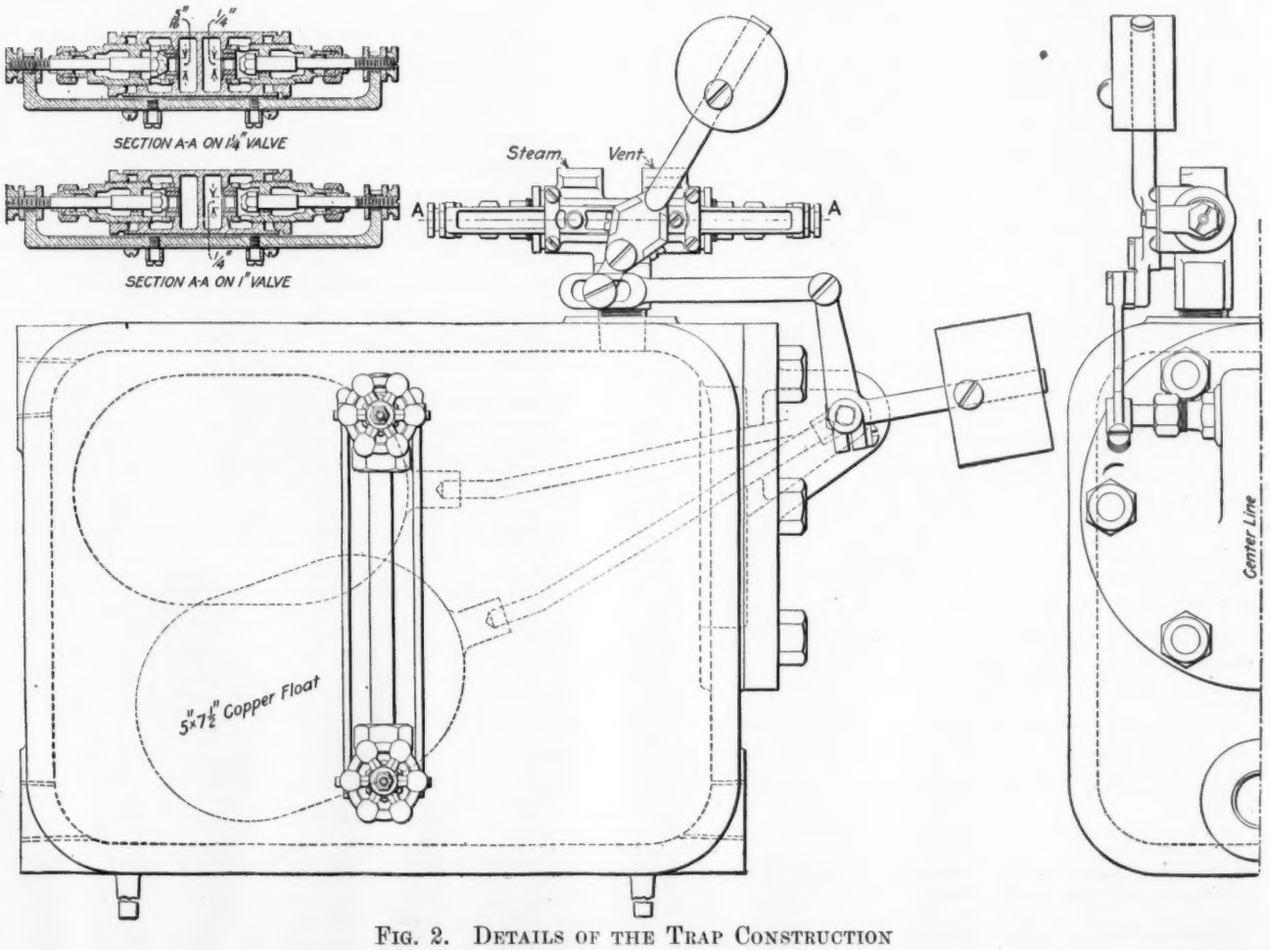


FIG. 2. DETAILS OF THE TRAP CONSTRUCTION

Fractional Horsepower Motors*

By Bernard Lester

SYNOPSIS—The development in the design and construction of the single-phase motor is traced from its origin to the present time, and the operating characteristics of the commoner types of single-phase motors are described and illustrated by the use of speed-torque curves.

During the last ten years the field for the use of fractional horsepower motors has increased enormously and many new devices have become available commercially. There have been three principal causes for this development in the small-motor field:

1. Efficiency engineering in every field of endeavor has brought to the mind of the public the realization of the saving that can be accomplished in time, labor and money by operating small appliances electrically.

2. Wide distribution of central-station circuits, primarily for the purpose of lighting, has greatly increased the possible field for the use of small motors.

3. The performance of the small motor as a reliable source of power and its proper application have established the confidence necessary to encourage the investment of time and money in the development of the industry.

Since single-phase, alternating-current distribution is so largely employed for lighting and, consequently, is available as a supply for small motor-driven machines, the development of a simple, reliable and efficient small single-phase motor has had a large share in the growth of this industry. Single-phase motors of the series, repulsion or induction type, or some modifications or combinations of these principal types, have been largely used.

Series Motor

The series single-phase motor, owing principally to its varying speed with change in torque, has a limited application. It can be safely used only where the load is rigidly connected to the driving shaft and where large variations in speed are permissible with variations in load. This type of motor is successfully used with fans attached to the motor shaft, and for exhausting or supplying air, as in the case of fan-type vacuum cleaners or forge blowers; also for portable electric tools, in which case the power is turned off when the tool is not in actual service. Its use, however, is limited to these or similar applications. A great advantage in the series motor, when especially constructed, is that it can be operated upon direct current or alternating current of most commercial frequencies and the same voltage, with speed-torque characteristics sufficiently similar to produce results generally satisfactory in motors of small capacity.

Repulsion Motor

The single-phase repulsion motor, which is a modification of the series motor, possesses in general the same limitations in regard to its speed-torque characteristics as the series motor. However, without load it does not attain the same dangerously high speed. Since the brushes are short-circuited, the interchangeability from alternating- to direct-current circuits does not exist.

Induction Motor

The single-phase induction motor possesses a speed-torque characteristic in which the speed holds practically constant under a varying torque. This is well suited to the large majority of small motor-driven machines, provided a means is supplied to bring the rotor up to a speed at which the inherent torque produced is sufficient to accelerate the load.

The split-phase induction motor is by far the most common type in fractional horsepower sizes. The most difficult problem has been in overcoming the absence of starting torque in the simple single-phase motor, and the principal steps in this development will be mentioned.

The first split-phase, self-starting motor was developed by Tesla and used for driving small desk fans, but was not employed generally for power service. Several years later, about 1893, single-phase induction motors of larger capacities were developed and used, but as there was no device for starting the motor, it had to be started by hand. Like any polyphase induction motor, when connected to a single-phase circuit and operated on one phase only, it would run in either direction, if started by some external force and accelerated to a point at which the torque developed by the primary of the motor upon the rotating element was sufficient to carry the rotor up to speed. The speed-torque curve of such a motor is shown in Fig. 1, curve AD. From 1893 to 1895 self-starting split-phase motors were designed with two windings in the primary—one for running and the other for starting. A phase splitter, consisting of a manually operated external switch and resistance, connected the primary windings to the supply circuit and inserted resistance in the starting winding. A phase displacement in this way existed between the currents in the two windings, which exerted a torque upon the rotor in starting, the starting winding and resistance being cut out as soon as the motor came up to speed. Later, motors were designed with starting devices supplied with a condenser in place of a resistance. This produced a greater angular advance in the phase displacement than was the case with the resistance starter. In this particular, therefore, a somewhat improved operating characteristic was obtained, due to higher power factor, the condenser remaining in the circuit while starting and running.

About 1898 single-phase induction motors were designed, which started as series motors. The secondary winding was similar to that of a series motor, the commutator bars being short-circuited as the armature accelerated, after which the motor ran as an induction motor. Shortly after this an advantage was found in starting as a repulsion instead of a series motor, since the motor so constructed could be connected externally for use either upon 110- or 220-volt circuits. Motors designed in accordance with this principle are now widely used, especially in sizes above ½ hp. An automatically operated centrifugal governor within the rotating element short-circuits the commutator bars. Curve B, Fig. 1, shows the speed-torque characteristics of such a motor while starting compared with that of the induction motor (curve AD). The line ab represents the speed at which the motor automatically switches from a repulsion to an induction motor.

Another development in the split-phase motor was in the use of an external clutch or clutch pulley. Owing to difficulty in obtaining sufficient starting torque to enable the motor to be used for other than accelerating very light loads, centrifugal clutches were used, allowing the rotor and shaft to accelerate to a point at which a liberal torque was exerted

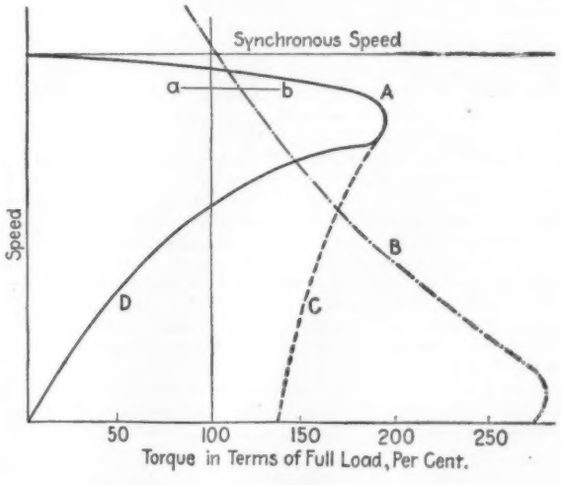


Fig. 1. Speed-Torque Curves

by the rotor; at this point the clutch took hold and applied the load to the motor. Within the past few years marked improvements have been made and sufficient starting torque can now be obtained without the use of a centrifugal clutch, for many classes of service. A light, high-resistance starting winding, in addition to the running winding, is used. Curve AC, Fig. 1, shows a typical speed-torque of such a motor. This starting winding is cut out by means of a centrifugally operated switch placed within the motor and at a speed slightly below that corresponding to full load.

*Excerpts from paper presented at Cleveland Section, A. I. E. E., Mar. 19, 1915.

It is interesting to note that small-motor engineers encounter almost identically the same problems as those which apply to larger industrial motors, in so far as cycles of operation and speed-torque requirements are concerned. For instance, in the application of small motors to washing machines with wringers, the wringer is the limiting feature, taxing the motor with sudden peak loads. This application may well be compared with a motor-driven rolling mill. The

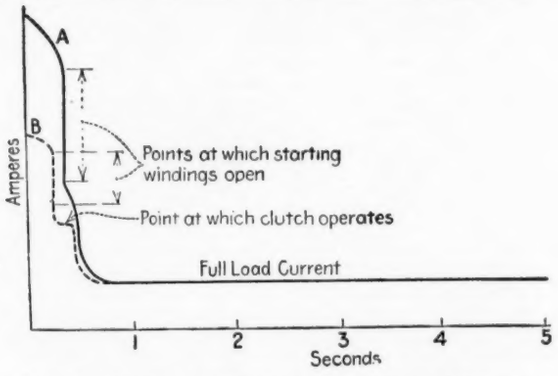


FIG. 2. CURVES SHOWING STARTING CURRENT

motor-driven meat grinder compares closely with the motor-driven pulp-mill beater, and the coffee grinder with the rock or stone crusher. In the design of high-speed motors for fan-type vacuum cleaners, the problems closely parallel those of the high-speed turbo-blower.

In applying split-phase motors, aside from the general characteristics outlined elsewhere, special attention must be given to those characteristics of starting torque, pull-out or maximum torque and temperature rating. The starting torque varies approximately as the square of the impressed voltage; consequently, any reduction in the voltage of the circuit produces more than a proportional reduction in torque. Furthermore, the starting current of split-phase motors materially exceeds the full-load running current. This factor, in addition to light wiring or insufficient transformer capacity, often results in a reduction in starting torque. Good practice in small-motor application provides that the motor should be able to start the driven machine when the impressed voltage is as low as 20 per cent. below the rated voltage. A centrifugal clutch is often incorporated in the design of the motor, not only to insure an ample starting torque and reduce the effect of the current taken during starting, principally by cutting down the time during which it is taken, but also to provide an element of flexibility in the case of a machine rigidly connected to the motor. The clutch will slip in the event of sudden or extreme overload, thus protecting the combined unit.

New Federal Employment Offices

The Department of Labor, through the Division of Information of the Bureau of Immigration, has recently established distribution branches throughout the country for the purpose on the one hand of developing the welfare of the wage earners of the United States and improving their opportunities for profitable employment, and on the other hand of affording to employers a method whereby they may make application for such help as they need, either male or female, citizens or alien residents, and have their wants supplied through the distribution branches. No fee is charged employer or employee for this service.

The following is a list of the headquarters, together with the states comprising the zone or jurisdiction over which they, respectively, have control:

Zone No.	Location of Branch	Local Address	States or Territory Controlled
1	Boston, Mass.....	Long Wharf.....	Maine, Massachusetts, Rhode Island.
2	New York, N. Y..	United States Barge Office..	New York, New Jersey, Connecticut, New Hampshire, Vermont.
3	Philadelphia, Penn.	Gloucester City, N. J.....	Pennsylvania, Delaware, West Virginia.
4	Baltimore, Md...	Stewart Building.....	Maryland.
5	Norfolk, Va.....	119 West Main Street.....	Virginia, North Carolina.
6	Jacksonville, Fla..	Federal Building.....	Florida, Georgia, Alabama, South Carolina.
7	New Orleans, La.	Immigration station.....	Louisiana, Mississippi, Arkansas, Tennessee.
8	Galveston, Tex...	Immigration station.....	Texas, New Mexico.
9	Cleveland, Ohio..	Post Office Building.....	Ohio, Kentucky.
10	Chicago, Ill.....	845 South Wabash Ave....	Illinois, Indiana, Michigan, Wisconsin.
11	Minneapolis, Minn.....	Federal Building.....	Minnesota, North Dakota, South Dakato.
12	St. Louis, Mo....	Chemical Building.....	Missouri, Kansas, Oklahoma, Iowa.
13	Denver, Colo.....	Central Savings Bank Building.....	Colorado, Wyoming, Nebraska, Utah.
14	Helena, Mont....	Power Building.....	Montana, Idaho.
15	Seattle, Wash....	Fifteenth Avenue, West and Blaine Streets.....	Washington.
16	Portland, Ore....	Railway Exchange Building.	Oregon.
17	San Francisco, Cal	Angel Island.....	California, north of the northern boundary of San Luis Obispo, Kern, and San Bernardino Counties; also State of Nevada.
18	Los Angeles, Cal.	Post Office Building.....	California, south of the northern boundary of San Luis Obispo, Kern, and San Bernardino Counties; also State of Arizona.

All of the postmasters throughout the United States are coöperating in this work by distributing application blanks both to employers and employees. The appropriate blanks may therefore be had on request to any postmaster. However, in those cities designated as zone headquarters application for blanks or information should be made direct to the Inspector in Charge of the Distribution Branch at the office of the Immigration Service at the address indicated in the foregoing table.

Western Hydro-Electric Development

The Montana Power Co., which is attempting to enter the Cœur d'Alenes, Idaho, in competition with the Washington Water Power Co., has 101,000 hp. of hydro-electric plants in operation, 120,000 hp. under construction, 127,000 hp. of undeveloped water-power sites and 8000 hp. of steam reserve. A second unit of Prickly Pear Valley irrigation project will be completed this spring and an additional 3500 acres served with water in 1915.

During the last three months of 1915, according to the report for the year ending Dec. 31, 1914, the company expects to receive a large additional revenue from railway electrification now under way on the Chicago, Milwaukee & St. Paul Ry. The Great Falls hydro-electric plant, which will have an ultimate capacity of 80,000 hp., will be in operation in July, and four of the six units of installation will be completed in the present year. Current is expected to be furnished from the Thompson Falls plant by June. Two units will be installed this year and two added as demanded. About 75 per cent. of the work at these two developments has been completed. The Hauser Lake plant has been increased to 34,400 hp. and the Black Eagle plant to 5100 hp. Sixty-seven miles of additional transmission lines were placed in operation in 1914.

Convention Dates for 1915

National Association of Stationary Engineers, Columbus, Ohio, Sept. 13-18.

American Order of Steam Engineers, Atlantic City, N. J., June 21-25.

Universal Craftsmen Council of Engineers, Rochester, N. Y., Aug. 3-7.

Canadian Association of Stationary Engineers, Hamilton, Ont., July 27-29.

N. A. S. E. STATE CONVENTIONS

California	San Francisco	May 27-28
Colorado	Denver	Aug. 6
Connecticut	Hartford	June 25-26
Illinois	Decatur	May 26-28
Indiana	Richmond	June 9-12
Iowa	Clinton	June 2-4
Kansas	Wichita	May 5-7
Kentucky	Lexington	June 10-12
Michigan	Jackson	June 23-25
Minnesota	Mankato	July 7-9
Missouri	St. Louis	May 19-21
New England	Holyoke, Mass.	July 7-10
New Jersey	Trenton	June 3-6
New York	Auburn	June 11-12
Ohio	Columbus	Sept. 12-13
Pennsylvania	Pittsburgh	June 18-19
Texas	Dallas	.....
West Virginia	Clarksburg	.....
Wisconsin	Sheboygan	July 22-24

The Temperature at Which Water Boils depends on the pressure upon its surface. At 1 lb. absolute its highest temperature is 102 deg. F.; at 14.7 lb., 212; and at 300 lb., 417.5 deg. (see steam tables).

Recent Court Decisions

Digested by A. L. H. STREET

Duty to Safeguard Children Against Wires—An electric-power company which knew that boys were accustomed to play on a wall near an electric wire carrying a dangerous voltage was bound to maintain the wires in safe condition, and, therefore, is liable for the death of a boy who came in contact with a wire where it was uninsulated, according to the decision of the New York Supreme Court announced in the case of Meehan vs. Adirondack Electric Power Co., 150 "New York Supplement," 714.

Care in Handling Electricity Standardized—The degree of care required in the maintenance of electric wires is declared by the Washington Supreme Court, in the recent case of Card vs. Wenatchee Valley Gas & Electric Co., 137 "Pacific Reporter," 1047, to depend upon the character of the current carried, slight care being sufficient where the current would not injure persons coming in contact with it and the highest care being required where the current would cause death or serious injury. The court finds that the jury were warranted in finding that an electric-power company was negligent in failing to insulate a high-power wire which was strung only 17 ft. above the land of one who was killed through inadvertently bringing a pipe in connection with the wire while repairing an irrigation ditch.

Proving Negligence in Explosion—In suits for injuries from boiler explosions, it often becomes difficult to establish the cause as a basis for holding the owner responsible if it appears that the accident was due to negligence attributable to him. This question arose in the recent case of Gill vs. Brown (169 "Southwestern Reporter," 752), which was passed upon by the Tennessee Supreme Court, and it was sought to hold an employer liable for injuries sustained by plaintiffs while at work in the former's sawmill, caused by the explosion of a steam boiler, on the theory that the mere occurrence of the explosion raised a presumption of negligence, in the absence of affirmative proof to the contrary on the employer's part. But the court held that the mere fact of an explosion does not change the rule of law which places the burden on the plaintiff in every personal-injury action to clearly establish the fact that the injury complained of was produced by some negligence attributable to the defendant. The court, however, held that proof in this case that the boiler was very old (the evidence tended to show that it had been used for 40 years) and the finding of several rusted rivets in the wreckage warranted a finding that the boiler had been negligently permitted to remain in a dangerously defective condition.

PERSONALS

Alfred Kauffmann is now vice-president of the Link-Belt Co. in charge of operations at Indianapolis. Mr. Kauffmann served in the engineering department at Philadelphia for a number of years, from which he was promoted to take charge of the erection work of the company. He was later transferred to the sales department, looking after the coal-mining business in the East and particularly in the West Virginia field. His many friends will be glad to learn that in recognition of his competent and able work he has been elected vice-president of the Link-Belt Co.

ENGINEERING AFFAIRS

The American Iron and Steel Institute will hold its eighth general meeting at the Waldorf-Astoria, New York, on May 28 and 29. The program, which will be announced in the near future, will contain only a few formal papers in order to encourage informal discussion.

The Detroit Engineering Society announces the following meetings: May 7 Mr. John O'Connor, Jr., of the Mellon Institute of Industrial Research, will speak on "Some Points in the Indictment of the Smoke Nuisance;" May 21 Mr. H. M. Brinckerhoff is expected to give his deferred talk on the "Detroit Traffic Situation."

Boston Association No. 12, of the National Association of Stationary Engineers, will celebrate its twenty-first anniversary with a ladies' night at 995 Washington St., on the evening of May 3. All members of the N. A. S. E. and their families are invited to be present.

Pratt Institute, Brooklyn, N. Y., exhibits the work of day students on Apr. 29, 2 to 10 p.m.; Apr. 30, 10 a.m. to 10 p.m., and May 1, 10 a.m. to 5 p.m. The students will be engaged at their regular work, and the engineering public is invited to inspect especially the methods and equipment of the School of Science and Technology.

International Engineering Congress—Volume II of the Transactions of the International Engineering Congress to be held in San Francisco, Sept. 20 to 25, will comprise two series of papers, one on the subject of waterways and one on irrigation. The former subject will be treated under four general topics with possibly two additional. These topics cover the general field of the province of waterways in internal commerce, economic aspects, physical features, natural waterways, towage and propulsion. Irrigation will be treated under 11 topics covering: Methods of handling irrigation enterprises; duty of water; relation between demand and supply; underground sources; stream sources; tail water from hydro-electric plants; regulations for use; methods of charge; metering; drainage; dams in general; and also recent developments in India and in the Argentine Republic. This volume will comprise from 20 to 25 original illustrated papers, together with contributed discussions. The transactions of the Congress as a whole will include from seven to nine other volumes, covering the various fields of engineering work. Membership in the Congress with the privilege of purchasing any or all of the volumes of the proceedings is open to all interested in engineering work. Full particulars may be obtained from W. A. Cattell, secretary, 417 Foxcroft Building, San Francisco, Calif.

BOOKS RECEIVED

DIRECT-ACTING STEAM PUMPS. By Frank F. Nickel. McGraw-Hill Book Co., Inc., New York. Cloth; 258 pages, 6x9¼ in.; 218 illustrations; tables. Price, $3.

ENGINEERING ECONOMICS. By J. C. L. Fish. McGraw-Hill Book Co., New York. Cloth; 217 pages, 6x9½ in.; illustrations; tables. Price, $2.

NEW PUBLICATIONS

STEAM TURBINES. By James A. Moyer. Published by John Wiley & Sons, New York, 1915. Second edition. Cloth; 376 pages; 6x9 in. Price, $3.50.

While intended as a manual for those operating, designing or manufacturing steam turbines, an outline of elementary thermodynamics and of the use of entropy and velocity diagrams is given. The part of the text relating to the design of nozzles and blades is valuable as an explanation of the theory, but the lack of detailed proportions and dimensions prevents its being of much use to designers. Since the first edition was issued, new applications of turbines have come into use, and accordingly, in the second edition Professor Moyer has either added or revised chapters on low-pressure, mixed-pressure and bleeder turbines. The essential elements of commercial types of turbines are clearly described and the methods of testing explained. With the exception of the numbering of the illustrations, the arrangement of the book is excellent. But to look at Fig. 192, which precedes Fig. 206, in turn followed by Fig. 195, gives the impression that the illustrations, in reality a most valuable part of the book, were an after-thought. The volume also contains interesting chapters on power-plant costs, an outline of plant design, and a theoretical discussion of gas turbines.

POURING OF BABBITT METALS

In a treatise on the "Pouring of Babbitt Metals," the Syracuse Smelting Works, of Brooklyn, N. Y., offers suggestions which every engineer would do well to follow: Among other things it says:

Better service may be obtained if you will learn that it is of the utmost importance to pour babbitt metals at a low temperature.

When practical, take the chill off the mandrel and shell by warming, as this will dry off the moisture which causes blow-holes, and also makes the metal flow better.

On the subject of remelting metals is the following:

Instructions are generally given to stir before pouring. Those who give these instructions intelligently do so because the tendency is to pour metals too hot and the stirring lowers the heat.

This dispels the idea which many engineers have, that the

purpose of stirring the molten metal is to reunite the separated alloy.

To determine whether the melted metal needs cleaning, it advises that the surface be examined while it is at a fair pouring heat. If fine, spider-web lines appear on the surface after skimming, the metal is clean.

OXYACETYLENE WELDING AND CUTTING. By Calvin F. Swingle, M. E., author of "The Twentieth Century Handbook for Steam Engineers and Electricians," etc. Chicago: Frederick J. Drake & Co. Size, 4½x6¾ in.; 185 pages; 76 illustrations; indexed. Price, cloth, $1 net; leather, $1.50 net.

This volume deals with many types of generators and portable apparatus in detail, together with the chemical properties and considerations of the gases used. There are numerous illustrations of different types of equipment, with notes on the mode of operation.

The chapters on torches, their management and characteristics are instructive, and useful information is given relating to the consumption of gas and methods of handling, with illustrations, weights and dimensions of torches in general use. Actual welding and cutting work could with advantage have been treated at greater length and illustrated with practical examples giving information on the work done by others and conclusions to be drawn therefrom. The impression that this mode of welding is applicable to everything should be avoided. While its uses are increasing, other forms still have a very large field where the oxyacetylene method is too costly and uncertain in its results. Costs of operation could also have been dealt with to advantage. The illustrations are not all that could be desired, but the book is well indexed; and no doubt will find favor among those interested in the apparatus required but who do not wish highly technical descriptions.

Though the names of some of the makers of apparatus are included, they are few. That of the Davis-Bournonville Co. is an especially conspicuous omission, in view of the great amount of pioneer work which this company did in introducing the art into this country. Some authors inject too much advertising into their books to have them wholesome, but this one seems to have gone to the other extreme. Credit should be given where credit is due, especially when it will be of actual interest to the reader.

PREVENTING LOSSES IN FACTORY POWER PLANTS. By David Moffat Myers. New York: The Engineering Magazine Co. Cloth; 5¼x7½ in.; 560 pages; 68 illustrations. Price, $3.

That the saving of coal in our industrial plants is necessary for the present generation, as well as those to come, can hardly be denied. The monetary saving effected today, while enabling us to procure certain improvements in our plants, to give better working conditions to our employees, higher wages, and increased dividends, is only one side of the question; possibly that uppermost in our minds, but the consequent conservation of our available coal fields is of greater importance to posterity.

Power-plant efficiency has made considerable progress in the past few years, but still not as great as efficiency applied to other lines of business, possibly because the efficiency engineer meets with greater obstacles in this field. It is usually easy to convince the manager of an industrial plant of the advisability of installing a machine that will enable him to cut down his labor or double his output; it is simply a matter of the cost of the machine installed and its earning power.

When the efficiency engineer seeks to impress this same man with the saving that can be effected through the employment of proper methods applied to the coal pile, he usually meets with considerable uphill work, and frequently with ill-concealed skepticism. Managers and owners, when approached on this subject, are prone to reply that they have made very good arrangements with their coal dealer, that they have good firemen, the steam they are allowing to go up in the air does not amount to much anyway, and kindred other replies only too familiar to engineers that have tried to lead them back to the path of efficiency. Some again, will realize that there is waste in exhausting to atmosphere, the use of bare steam pipes, the use of long and badly arranged shafting, the unintelligent handling of boilers and coal. These men are indeed wise and, regrettably, too few.

The work under review deals with this important subject in a clear and illuminating manner and should be of great benefit to all engaged either in the owning, operating, designing or rehabilitating of power plants, great or small. The theory and practice are ably explained. Every item of loss, with its consequent result, is traced in successive steps from its origin back to the coal pile. Methods of prevention, together with actual examples from the author's wide experience, are carefully shown.

The engineers at present exploiting this field, or those who may have this intention, would do well to read this work and apply the principles therein. Many useful tables and tabular results of actual tests are given.

The author undoubtedly intends the volume to be read in its entirety, as no index is provided. The subject, to be thoroughly appreciated, must be completely read.

BUSINESS ITEMS

Arthur G. McKee & Co., contracting engineers, of Cleveland, Ohio, have issued an attractive brochure, elaborately illustrated with examples of their work.

The Indiana Steel Co., Gary, Ind., has installed "Diamond" Soot Blowers, made by the Diamond Power Specialty Co., Detroit, Mich., on 26 boilers.

The Chicago Pneumatic Tool Co., Chicago, Ill., has removed its New York office from 50 Church St. to 52 Vanderbilt Ave., and its Boston office from 191 High St. to 185 Pleasant St.

L. R. Merritt & Co. has removed its office from 95 Liberty St. to larger quarters in the Vanderbilt Concourse Bldg., 52 Vanderbilt Ave., New York. This company represents the Brownell Co., Springfield Boiler & Mfg. Co., Craigs Ridgway & Son Co., Coppus Engineering & Equipment Co., Advance Pump & Compressor Co., James McMillan & Co.

The Harrison Safety Boiler Works, 17th and Clearfield St., Philadelphia, Penn., is sending out Cochrane "Engineering Leaflet" No. 18. This 48-page booklet contains an article by W. S. Giele entitled "Laboratory for Investigating and Testing Liquid Flow Meters of Large Capacity" and an article by James Barr, B. Sc., entitled "Experiments Upon the Flow of Water Over Triangular Notches." Copies are mailed on request.

Bird & Son, E. Walpole, Mass., has recently ordered of Builders Iron Foundry, Providence, R. I., a venturi meter with type M indicator-recorder for boiler feed service. This constitutes the fourth venturi meter installed by this company for measuring boiler feed water. The Inland Steel Co., of Indian Harbor, Ind., recently ordered an 8-in. venturi meter tube with type M register-indicator-recorder for boiler feed service.

"Retail Coal Pockets, Third Edition" is now being distributed by the Guarantee Construction Co., 142 Cedar Street, New York. Specialists in constructing buildings and apparatus for handling coal and ashes for power plants. This 32 page 6 by 9 booklet illustrates many pockets recently erected by them, describes modern coal handling methods, and explains which are most suited to various conditions. A copy will be mailed on request.

Recent installations of American standard copper coil feed water heaters, made by the Whitlock Coil Pipe Co., Hartford, Conn., include: Hainesport Mining & Transportation Co., Philadelphia, Penn., 600-hp. for its dredge "Philadelphia;" Lake Champlain Transportation Co., Whitehall, N. Y., 100-hp.; L. M. Hartson Co., No. Windham, Conn., 50-hp.; Metropolitan Water and Sewerage Board, Boston, Mass., 150-hp.; Chatham Bars Inn, Chatham Bars, Mass., 80-hp.; Brawn-Willard Co., Portland, Maine, 100-hp.; Rhode Island Mill, Spray, N. C., 500-hp.; Northwestern Electric Co., Portland, Ore.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance

Positions Open, (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Opportunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books), **For Sale,** 5 cents a word, minimum charge, $1.00 an insertion.

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No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

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MASTER MECHANIC for rolling mill. P. 487, Power.

A CENTRIFUGAL PUMP DESIGNER with experience in designing high-speed pumps of small and medium sizes for high- and low-head service; applicants must state fully their experience, age and salary expected. P. 491, Power.

POSITIONS WANTED

CHIEF ENGINEER, employed in central station; seven years' experience with engines, turbines, dynamos, boilers; married; age 30. P. W. 488, Power, Chicago.